UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

June 19, 2000

Memorandum

SUBJECT: AGRICULTURAL AND OCCUPATIONAL EXPOSURE ASSESSMENT AND RECOMMENDATIONS FOR THE REREGISTRATION ELIGIBILITY DECISION DOCUMENT FOR CHLORPYRIFOS

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DP Barcode:	D263893
Pesticide Chemical Codes:	059101
EPA Reg Nos:	62719-38, -221, -23, -245, -34, -79, -72, -166, -220; 34704-66; 499-367, and 10350-22
EPA MRID No.:	430279-01, 429745-01, 431381-01 and 02, 444835-01, 430420-02, 429944-01 and 02, 430627-01 and 02
PHED:	Yes, Version 1.1

AGRICULTURAL EXPOSURE/RISK ASSESSMENT AND CHARACTERIZATION

EXECUTIVE SUMMARY

This document contains the occupational exposure assessment for agricultural, animal premise, and ornamental uses of chlorpyrifos. The document also includes potential risk mitigation measures such as personal protective equipment (PPE) and engineering controls for handlers and proposed restricted entry intervals (REIs) for postapplication activities. The scope of the document covers both Worker Protection Standard (WPS) including typical agricultural uses (e.g., citrus, vegetable crops, tree fruits, etc.), greenhouse uses, outdoor ornamental uses, and sodfarm uses and nonWPS uses, including animal eartags and ornamental uses in non-commercial settings. Exposures resulting from residential uses and exposures resulting from Pest Control Operators (PCOs) in residential settings are outside of the scope of this document.

Chlorpyrifos is an organophosphate insecticide used to control various insects such as grasshoppers, aphids, fire ants, etc. Chlorpyrifos is formulated as many end use products including products intended for agricultural uses, such as a wettable powder packaged in water soluble packets, granular, and soluble concentrate/liquids. The dry flowable formulation and the open packaging of wettable powders are no longer supported by the registrants, and therefore, not assessed in this document. A wide variety of application techniques have been identified that could potentially be used to apply chlorpyrifos, such as tractor-drawn equipment, open and closed mixing/loading, and hand held equipment. Applications of chlorpyrifos also include soil incorporated/directed uses, bark treatments, and foliar treatments.

The application rates used in the assessment are intended to reflect the maximum rates on the labels, and in some instances, the rates assessed also include values Dow AgroSciences (DAS) specifically requested to be included as “typical”. *Maximum rates are always used in the assessment to provide a risk evaluation for those individuals that may use the label as approved by the Agency and to ensure adequate/complete product stewardship.* Rates other than the maximum are also often included to provide additional characterization of the actual uses in the field for risk management purposes (e.g., reducing rates as part of the risk mitigation). To further characterize chlorpyrifos typical use conditions, DAS has recently submitted a market survey (Mar-Quest) on use rates and the Agency is currently reviewing the results. Examples of the application rates used in this assessment include, but are not limited to the following: vegetable crops range from 1 to 2 lb ai/acre; maximum citrus rate is 6 lb ai/acre; the maximum rates for tree nuts and fruits is 2 lb ai/acre; outdoor ornamental rates for wettable powders are up to 4 lb ai/acre and up to 0.16 lb ai/gallon for liquid formulations; and up to 8 lb ai/acre for fire ant control in sodfarm turf just prior to harvest. The predominant maximum application rates listed in Table 3 are defined as those rates which are most frequently cited in the labels and are also believed to be representative of the maximum allowable rates that would not underestimate exposure.

Acute toxicity categories for the technical grade are Toxicity Category II for oral, dermal, and inhalation. It is a Toxicity Category III for primary eye and dermal irritation. The endpoints used in this document to assess chlorpyrifos hazards include short- and intermediate-term endpoints. A route specific short-term dermal NOAEL of 5 mg/kg/day from a 21-day dermal rat study has been identified, and therefore, a dermal absorption adjustment is not necessary. The dermal LOAEL in this study of 10 mg/kg/day is based on plasma and red blood cell (RBC) cholinesterase inhibition (ChE) of 45 and 16 percent, respectively. The intermediate-term NOAEL used in the postapplication assessment for dermal exposures is converted from an oral NOAEL of 0.03 mg/kg/day based on a weight of the evidence from 5 oral studies in dogs and rats for RBC ChE inhibition. RBC cholinesterase inhibition occurred at 0.1 to 0.3 mg/kg/day (LOAELs). A dermal absorption factor of 3 percent is applied to this oral NOAEL. Evaluation of biomonitoring data was conducted based on a comparison of the absorbed dose as measured by urinary excretion of 3,5,6-trichloro-2-pyridinol (3,5,6-TCP), to the oral equivalent NOAEL of 0.15 mg/kg/day (i.e., 5 mg/kg/day from 21-day dermal study x 0.03 dermal absorption) because the majority of exposure is via the dermal route. The short- and intermediate-term inhalation NOAEL is 0.1 mg/kg/day from two separate 90-day rat inhalation studies. There were no effects seen in either of these studies at the highest dose tested. However, at higher oral doses of 0.3 mg/kg/day RBC ChE was observed in animals. An uncertainty factor of 100 is used for all endpoints (i.e., 10x for intra species and 10x for interspecies variability). MOEs of greater than 100 do not exceed the Agency's level of concern. Because the same adverse effect (i.e., ChEI) was seen following dermal and inhalation exposures, MOEs for these routes of exposure can be combined.

The exposure duration for short-term assessments using the 21-day dermal study is appropriate for assessing occupationally exposed individuals for up to 30 days of continuous use. Intermediate-term exposure durations are assessed using a weight of the evidence from five (2 weeks to 2 years) oral studies and are used to assess those individuals that are exposed continuously for 1 to 6 months. Handler risks are assessed using the short-term exposure duration. Although information is not available to determine what percentage of applicators apply chlorpyrifos continuously for more than 30 days, it is reasonable to believe that those individuals will represent a very small segment of the agricultural applicators. Nigg and Knaak (2000) recently published an article recommending a blood esterase monitoring program for pesticide (OPs) handlers. This type of a program would be valuable in identifying specific individuals for mitigating chlorpyrifos risks, especially that subpopulation that may handle the chemical for more than 30 days. No chronic (i.e., more than 180 days per year) agricultural or ornamental uses have been identified.

Multiple **handler** exposure studies were conducted by the registrant and submitted to the Agency. The handler data collected included biological monitoring and passive dosimetry data. In most of the studies, the absorbed doses indicate that the level of PPE worn by the test subjects did not mitigate exposures to such a degree that MOEs were above the target of 100. These biological monitoring data submitted by DAS indicate that additional risk mitigation measures are necessary to achieve the targeted MOE of 100. These data submitted by DAS, along with surrogate data from the Pesticide Handlers Exposure Database (PHED) Version 1.1, were used to assess the potential exposures resulting from handling chlorpyrifos. Potential exposures and absorbed doses were calculated using unit exposures (i.e., normalized to amount of active ingredient handled -- mg/lb ai handled) from both passive dosimetry and biological monitoring (mg/kg-BW/lb ai) data multiplied by the amount of chlorpyrifos handled per day (i.e., lb ai/day). The amount of chlorpyrifos assumed handled per day was derived from the various application rates and the number of acres (or gallons of spray solution) that could be applied in a single day. Dermal and inhalation MOEs are presented separately along with a combined total MOE. Uncertainties inherent in these calculations and their effects on the reported MOEs are discussed in Sections 2.1.3 and 2.2.2.

The **results** of the short-term handler assessments indicate that only 1 of the 16 potential uses did not provide at least one application rate with a total MOE(s) greater than or equal to 100 at either the **maximum PPE** (i.e., coveralls over long pants, long sleeved shirts, and chemical resistant gloves while using open systems) or using **engineering controls** (i.e., closed systems). Section 2.2.2 (*Summary of MOEs*) provides a detailed summary and characterization of the MOEs. There are no data, chemical-specific or surrogate, to assess 3 of the 16 uses. In total, exposure and risk estimates were calculated for 56 scenarios within the 16 uses (i.e., multiple crops and application rates). Based on the maximum level of protection (i.e., various levels of PPE or engineering controls) 2 MOEs are estimated to be less than 10; 6 MOEs are between 10 and 50; 9 MOEs are between 50 and 100, and 39 MOEs are greater than 100. Fourteen of the scenarios were evaluated based on data obtained from five chemical-specific studies submitted by DAS. There is insufficient information (e.g., dermal and inhalation exposure data) to assess the seed treatment uses, dip applications (e.g., preplant peach root stock, nursery stock), and dry bulk fertilizer applications to citrus orchard floors. These scenarios may also be of concern given the results from the other scenarios assessed.

Multiple **postapplication** exposure studies were also conducted by the registrant and submitted to the Agency. These studies included biological monitoring and passive dosimetry data, along with dislodgeable foliar residue (DFR) data. Data were collected for sugar beets, cotton, sweet corn, citrus, almonds, apples, pecans, cauliflower, and tomatoes. These data were used in this assessment in conjunction with chemical-specific and HED standard values for transfer coefficients to assess potential exposures to workers reentering treated sites. Transfer coefficients which are used to relate human exposure from environmental residues are not available for all activities (e.g., harvesting). Additionally, DFR data are not available for all crops that are potentially treated with chlorpyrifos. Therefore, in the absence of data, the assessment of postapplication exposures in this document are based on a grouping of activities associated with various representative crops. The potential for dermal contact during postapplication activities (e.g., harvesting) is assessed using a matrix of potential dermal contact rates by activity and associated crops with groupings of "low", "medium", and "high". In addition to this matrix, citrus and tree nuts & fruits are assessed separately. If warranted, a more refined postapplication assessment could be conducted once the Agricultural Reentry Task Force (ARTF) data are available.

The **results** of the short- and intermediate-term postapplication assessments indicate that restricted-entry intervals (REIs) need to be established. The REIs range from 24 hours for the low, medium, and high crop grouping matrix to 10 days for harvesting cauliflower. In short, REIs are 24 hours for all crops except the following: cauliflower (10 days), all nut trees (2 days), all fruit trees (4 days), and citrus (5 days). The occupational postapplication assessment is believed to be reasonable high end representations of chlorpyrifos uses. The timing of the applications is noteworthy because most of the applications to trees are to the bark during the dormant to early season. Moreover, long preharvest intervals (PHIs) exist for most crops. Information is not available to estimate REIs for all uses. Even though there are insufficient information (e.g., timing of applications -- dormant/bark versus foliar treatments) and exposure data to assess postapplication activities for ornamental, sodfarm, and soil incorporated/directed uses, these uses are of concern to the Agency because of the high application rates and, in some cases, the high potential for dermal contact.

The handler and postapplication assessments are believed to be reasonable high end representations of chlorpyrifos uses. There are, however, many uncertainties in these assessments. The uncertainties include but are not limited to the following:

- extrapolating exposure and DFR data by the amount of active ingredient handled or applied;
- not all of the exposure data are of high confidence because of the lack of replicates and/or inadequate QA/QC results in the studies;
- using crop-specific DFR data to assess other crops; and
- application timing in comparison to actual potential postapplication exposure scenarios.

These uncertainties are inherent in most pesticide exposure assessments. The conservative nature of the assessments, however, are believed to be protective of the handlers and reentry workers.

Finally, as with most other pesticides, HED does not have adequate data to assess the potential for children's exposure in the home as a result of agricultural uses of chlorpyrifos. Environmental concentrations of chlorpyrifos in homes may result from spray drift, track-in, or from redistribution of residues brought home on the farm worker's clothing. Potential routes of exposure for children may include incidental ingestion and dermal contact with residues on carpets/hard surfaces. The level of an absorbed dose in a child resulting from the low level residues in carpet dust and/or soil are not known at this time. The Agency is, however, currently in the process of revising its guidance for completing these types of assessments. Modifications to this assessment shall be incorporated as updated guidance becomes available. Further research into children's exposures resulting from agricultural uses of pesticides are being conducted by the Agency's Office of Research and Development through the STAR (Science to Achieve Results) grant program. The STAR program can be accessed at ***http://es.epa.gov/ncerqa/grants/***

1.0 BACKGROUND

Purpose

In this document, which is for use in EPA's development of the Chlorpyrifos Reregistration Eligibility Decision Document (RED), EPA presents the results of its regulatory review of agricultural exposure to chlorpyrifos. The assessment of the *potential* human health effects are based on scenarios where the pesticide label's maximum recommended application rates are used for a full days work. Additional rates are also included to better characterize the risks associated what may be the most predominately used rates in the field. The maximum rates are always assessed because by approving a label, the Agency is in effect sanctioning its use as stipulated on the label. The maximum rates are also assessed to determine if risk mitigation is necessary given the Agency's selection of the toxicological endpoints and uncertainty factors. Historically, chlorpyrifos was assessed using a human toxicologically derived endpoint with a 10-fold safety factor. The Agency's current policy is to use the animal toxicology data and thus an additional 10-fold uncertainty factor is applied for interspecies variation. This need for an additional margin of exposure has resulted in the need for additional mitigation in the form of personal protective equipment or engineering controls.

Criteria for Conducting Exposure Assessments

An occupational exposure assessment is required for an active ingredient if (1) certain toxicological criteria are triggered and (2) there is potential exposure to handlers (mixers, loaders, applicators, etc.) during use or to persons entering treated sites after application is complete. For chlorpyrifos both criterion are met.

1.1 Summary of Toxicity Concerns Relating to Agricultural Exposures

Acute Toxicology Categories

Table 1 presents the acute toxicity categories as outlined in the Report of the Hazard Identification Assessment Review Committee dated April 6, 2000 (HED Doc. No. 014088).

Table 1. Acute Toxicity Categories for chlorpyrifos

Study Type	Toxicity Category
Acute Oral Toxicity	II
Acute Dermal Toxicity	II
Acute Inhalation Toxicity	II
Primary Eye Irritation	IV
Primary Dermal Irritation	IV
Dermal Sensitization	NA

Other Endpoints of Concern

The Report of the Hazard Identification Assessment Review Committee dated April 6, 2000 (HED Doc. No. 014088), indicates that there are toxicological endpoints of concern for chlorpyrifos. The endpoints, and associated uncertainty factors, used in assessing the risks for chlorpyrifos are presented in Table 2.

Table 2. Chlorpyrifos Hazard Endpoints and Uncertainty Factors.

Route / Duration	NOAEL (mg/kg/day)	Effect	Study	Uncertainty Factors	Comments
Short-term Dermal	5	Plasma and RBC cholinesterase inhibition of 45 and 16 percent, respectively, at 10 mg/kg/day	21-day dermal rat study	Intra species: 10x Interspecies: 10x	Dermal absorption factor not necessary
Intermediate-term Dermal	0.03	RBC cholinesterase inhibition at 0.1 to 0.3 mg/kg/day	Weight of evidence of 5 studies (2 year dog, 90 day dog, 2 year rat, 90 day rat, and DNT study)	Intra species: 10x Interspecies: 10x	3 percent dermal absorption.
Short- and Intermediate-term Inhalation	0.1	Lack of effects in 2 rat inhalation studies at the highest dose tested	Two 90-day rat inhalation studies	Intra species: 10x Interspecies: 10x	100 percent lung absorption assumed.

1.2 Summary of Use Pattern and Formulations

Chlorpyrifos [O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate], is an organophosphate insecticide currently registered for the control of various insects. Targeted pests include fleas, ticks, termites, cockroaches, cutworms, grasshoppers, aphids, etc. Registered use sites include grain crops, nut crops, cole crops, citrus, pome and strawberry fruits, forage, field and vegetable crops, sodfarms, ornamental plants, and poultry, beef cattle, sheep, livestock premise treatments (direct application to animals are prohibited, except ear tags). It can also be used in greenhouses. There are a wide range of application rates. Typical vegetable crops range from 1 to 2 lb ai/acre (up to 2.75 lb ai/acre for radishes); granular applications up to 3.0 lb ai/acre for tobacco; greenhouse up to 0.0066 lb ai/gal and outdoor ornamentals as high as 0.16 lb ai/gallon (pine seedlings); sodfarm fire ant treatments up to 8 lb ai/acre; citrus 6 lb ai/acre; and tree nuts and fruits at 2 lb ai/acre. Tables 3 and 4 in the following sections below provide more detailed information on application rates, EPA Reg. Nos., crops, and associated application equipment types. A multitude of application rates have also been assessed to provide additional characterization to give the risk managers more information for risk management decisions.

Only the occupational uses involving agricultural, animal premise, greenhouse uses, and sodfarms are addressed in this section. For the purposes of this chapter, relevant chlorpyrifos formulations include wettable powders packaged in water soluble packets (containing 50 percent a.i.), granular (containing 0.14 to 15 percent a.i.), impregnated ear tags, microencapsulated (containing 0.15 to 20 percent a.i.), and soluble concentrate/liquids (containing 0.5 to 62.5 percent a.i.). According to Dow AgroSciences (DAS), wettable powders packaged in open bags and dry flowables are no longer available and are being removed from active registrations. They are not assessed in this chapter.

1.3 Method and Types of Equipment Used for Mixing/Loading/Applying

The Agency determines potential exposures to pesticides handlers by identifying exposure scenarios from the various application equipment-types that are plausible given the label uses. It is HED's responsibility to assess all uses that are allowable/plausible based on the label. Therefore, in all cases, the maximum labeled rates are assessed. If these maximum rates do not reflect actual practice, then those rates should be removed from the labels. DAS has attempted to provide the Agency with a survey on actual uses (i.e., MarQuest Survey) and the Agency will include this information once it has been reviewed. For example, the frequency that the maximum labeled rates are used may be important information to the risk manger during the Agency's risk mitigation phase.

Based on reviewing pesticide labels and professional judgement, the use patterns specific to chlorpyrifos are associated with the following application equipment:

- Aerial (Spray) Equipment: foliar applications to fruit/nut trees, cranberries, field crops (e.g., alfalfa, sorghum/milo, wheat, soybeans, corn), cotton, vegetable crops, specialty crops (e.g., Christmas trees, mint, peanuts, sunflowers). Although sodfarms do use aerial applications, it is DAS contention that chlorpyrifos is not applied aerially to sodfarms. Aerial sodfarm applications are therefore not assessed and the label should be modified to prohibit aerial applications of chlorpyrifos.
- Aerial (Granular): corn, peanuts.
- Chemigation Equipment: field crops, cotton, cranberries, specialty crops, and ornamentals. The exposure to the handlers using chemigation equipment is represented by the mixer/loader and the amount handled is assumed to be equivalent to that of the aerial applications. Current chlorpyrifos labels prohibit chemigation on sodfarms; all future labels need to include this prohibition.
- Groundboom Equipment: fruit/nut orchard floors, cranberries, strawberries, field crops, cotton, vegetable crops, tobacco, outdoor ornamental soil treatment, sodfarm.
- Airblast Equipment: fruit & nut tree foliage and bark treatments.
- Backpack/Low Pressure Handwand Equipment: fruit/nut/ornamental tree bark treatments, grape vine-base treatments, stump treatments, outdoor/greenhouse ornamentals, and animal premises.
- High Pressure Handwand Equipment: greenhouse ornamentals.
- Hydraulic Sprayer with Handgun (i.e., rights-of-way type sprayer): fruit, nut, ornamental, Christmas tree bark/stump treatments, and animal premises.

- Dry Bulk Fertilizer: citrus floor (insufficient exposure data available to assess this use).
- Dip: peach/nectarine transplants (exposure data are not available to assess this use).
- Injector: potted/balled ornamental soil treatments (exposure data are not available to assess this use).

There is also a turfgrass/sodfarm use specifically listed on the label to be applied with a "mistblower". According to DAS, the mistblower is used to treat low underbrush, grassy areas, weeds, etc., to control ticks and chiggers. The use is for non sodfarm areas and should be removed from any sodfarm labels. Sodfarm applications are represented and assessed by groundboom applications.

2.0 HANDLER EXPOSURES

2.1 Handler Exposures & Assumptions

EPA has determined that there are potential exposures to mixers, loaders, applicators, or other handlers during usual use-patterns associated with chlorpyrifos. Based on the use patterns and potential exposures described above, 16 major agricultural, animal premise, and/or greenhouse exposure scenarios are identified to represent the extent of chlorpyrifos uses. Throughout the document the reference to these exposure scenarios are numerically organized (i.e., scenarios numbered 1 to 16). The mixer/loader scenarios are further denoted within each formulation by application type to account for the area treated (e.g., 1a mixing liquids for aerial applications and 1b mixing liquids for groundboom applications). The list of scenarios assessed are as follows:

(1) mixing/loading the liquid formulation to support (a) aerial, (b) groundboom, and (c) airblast applications;
(2) mixing/loading the wettable powder formulation to support (a) aerial, (b) groundboom, and (c) airblast applications;
(3) loading the dry (granular) formulation to support (a) aerial and (b) ground applications;
(4) applying the (a) liquid/wettable powder, and (b)granular formulations with aerial equipment;
(5) applying the liquid/wettable powder formulation with groundboom equipment;
(6) applying the liquid/wettable powder formulation with airblast equipment;
(7) applying the granular formulation with a tractor-drawn granular spreader;
(8) applying in commercial seed-treatment equipment;
(9) applying as a preplant-dip treatment;
(10) flagging for aerial spray applications;
(11) flagging for aerial granular applications;
(12) mixing/loading and applying with a back-pack sprayer;
(13) mixing/loading and applying with low-pressure hand-wand sprayer;
(14) mixing/loading and applying with a high pressure handwand (greenhouse uses);
(15) mixing/loading and applying a spray application to tree-trunks using tractor/truck-mounted hand-held sprayers (i.e., similar to rights-of-way treatments); and

(16) mixing/loading dry bulk fertilizer impregnation.

The potential exposures within the 16 identified exposure scenarios are assessed in this RED chapter using the toxicological endpoints and uncertainty factors associated with the active ingredient. Therefore, the PPE and engineering controls are determined by the assessment of the active ingredient and not the currently required risk mitigation measures on chlorpyrifos labels. This distinction of determining risk mitigation measures based on the active ingredient instead of the label required PPE is important because of the nature of the end-use products. The toxicological endpoint and associated uncertainty factors are often more sensitive than the end-use product's toxicity categories that were used to set the existing label PPE. On the other hand, some end-use products require additional PPE that are not necessary for the active ingredient because of the end-use product's potential for eye and/or skin irritation based on inerts.

A **deterministic approach** to assessing the potential exposure is presented. The Agency recognizes that the results from a **probabilistic analysis** would be more appropriate to define the distribution of exposure. However, HED's guidance on probabilistic analyses for nondietary exposures is still draft and the policy is not to regulate the occupational assessments using the probabilistic approach. Moreover, many of the MOEs reach the Agency's target using the high end estimates in a deterministic approach. As per Agency guidance (U.S.EPA 1992a) *"To conserve resources, most assessments are done in an iterative fashion, with a screening done first; successive iterations add more detail and sophistication. After each iteration, the question is asked, is this level of detail or degree of confidence good enough to achieve the purpose of the assessment? Resource-limited assessments should be evaluated in terms of what part of the original objectives have been accomplished, and how this affects the use of the results."* The "objective" of this chapter is to provide the Agency's risk managers with a risk assessment including a hazard evaluation (i.e., MOEs) and characterization of the chlorpyrifos uses based on the existing labels. To this end, the deterministic approach using a mix of central tendency to high end inputs provides risk managers with the appropriate level of detail for most scenarios.

Risk reflecting baseline attire (long pants, long sleeved shirt, and no gloves) is not presented in this chapter because of the need for additional PPE and/or engineering controls for all scenarios. There are some PPE, such as chemical-resistant aprons, that the Agency uses as qualitative measures because there are no recognized protection factors (PF) to assess their effectiveness. The Agency's risk managers require these types of PPE as additional mitigation. For example, chemical-resistant aprons are often required to protect mixer/loaders from accidental spills.

The scenarios are assessed using the following submitted studies along with surrogate data from PHED V1.1.

2.1.1 Submitted Studies

Mixer/loader/applicator exposure data for chlorpyrifos were required during the data callin (DCI) on September 18, 1991, since one or more toxicological criteria had been triggered. Requirements for applicator exposure studies are addressed by Series 875 Group A (formerly Subdivision U of the Pesticide Assessment Guidelines). The following five handler exposure studies were submitted by the registrant and are summarized below.

- **MRID No. - 430279-01.** Contardi, J.S. et al. 1993. Evaluation of Chlorpyrifos exposures during mixing/loading and application of Empire*20 insecticide to ornamental plants in greenhouses.

Passive dosimetry (dermal and inhalation) and biological monitoring (urine analysis) were conducted for 16 combined mixer/loader/applicator replicates. Of the 16 replicates monitored, 1 replicate was a low pressure handwand, 2 replicates were for backpack sprayers, and 13 replicates were for various types of high pressure handwands. The applications were made at various heights (i.e., floor, bench, overhead) to ornamental plants in a greenhouse. To summarize, an insufficient number of replicates were monitored for low pressure handwand and the backpack sprayer application techniques to meet the acceptability criteria outlined in Subdivision U of the Pesticide Assessment Guidelines. The quality control/quality assurance aspects of the passive dosimetry were adequate for the dermal whole-body dosimeters and inhalation canisters; however, the laboratory recovery results for the hand rinses were highly variable (i.e., 118.0 +/- 23.9 percent). The quality control/quality assurance aspect of the biological monitoring is sufficient, except that field spikes were prepared for only 10 of the 16 replicates (minimum of 2 field spikes per day of sampling). The data available from this study are of sufficient scientific integrity to be used in combination with available surrogate data to assess the exposure to those handlers.

	Mean ± std	Median	75^{th}%tile	90^{th}%tile	Range
Mixer/Loader/Applicator Backpack Sprayer					
2 replicates	Each of the two replicates handled 0.13 lb ai. Measured absorbed doses of 0.6 μg/kg and 0.1 μg/kg correspond to total estimated absorbed doses from passive dosimetry of 0.07 μg/kg and 0.09 μg/kg, respectively.				
Mixer/Loader/Applicator Hand-held Sprayer					
1 replicate	0.06 lb ai handled. Measured absorbed dose of 0.1 μg/kg compared to passive dosimetry adjusted absorbed dose of 0.13 μg/kg.				
High Pressure Handwand					
Amt Handled (lb ai)	0.47 ± 0.33 (n = 13)	0.52	0.78	0.88	0.07 to 0.94
Biological Monitoring (μg/kg)	1.15 ± 1.13 (n = 13)	1.0	1.4	2.14	0.1 to 4.2
Passive Dosimetry -- Total absorbed (3% dermal and 100% inhalation oral equivalent) dose (μg/kg)	3.85 ± 7.7 (n = 13)	0.70	2.37	8.73	0.21 to 28

Body weight from test subjects for both biomonitoring and passive dosimetry were used for comparison. A mean penetration factor from these replicates was used to estimate exposure under the coveralls. Note: These penetration factors are based on this specific study with new clothing, the values are not representative of HED's policy on protection factors.

- **MRID No. - 429745-01.** Shurdut, B.A. et al. 1993. Lorsban 4E and 50W insecticides: assessment of Chlorpyrifos exposures to applicators, mixer/loaders and re-entry personnel during and following application to low crops.

Passive dosimetry (dermal and inhalation) and biological monitoring (urine analysis) samples were collected for 9 replicates of open cab groundboom tractors, 6 replicates of open mixing of a 4EC formulation, and 3 replicates of open pour of a 50WP formulation. The applications were made preplant for cauliflower and tomato plants. To summarize, an insufficient number of replicates were monitored for each formulation for mixing/loading and for groundboom application to meet the acceptability criteria outlined in Subdivision U of the Pesticide Assessment Guidelines. The quality control/quality assurance aspects of the passive dosimetry were adequate for the dermal whole-body dosimeters, hand rinses, and inhalation canisters. The quality control/quality assurance aspects of the biological monitoring were sufficient. The data available from this study are of sufficient scientific integrity to be used in combination with available surrogate data to assess the risk to those handlers. The monitoring data from the study are presented in the table below for a comparison of the passive dosimetry to the absorbed dose. These results were not used "as is" because the study design was not representative of the maximum labeled rates and only monitored for a partial day. Therefore, the data when used in the risk assessment were extrapolated to represent the amount of chlorpyrifos that may be handled in a day.

	Mean ± std	Median	75^{th}%tile	90^{th}%tile	Range
Mixer/Loader of the 50W Formulation (open bag no longer supported by the registrant)					
Amt Handled (lb ai)	32.6 ± 13.5 (n = 6)	28.5	34.5	47	21 to 58
Biological Monitoring (μg/kg)	11.7 ± 6.9 (n = 6)	10.3	15.9	19.4	4.2 to 22
Passive Dosimetry **--** Total absorbed (3% dermal and 100% inhalation oral equivalent) dose (μg/kg)	32.5 ± 24.2 (n = 6)	29.8	53.1	59.4	3.8 to 61.7
Mixer/Loader of the 4E Formulation					
Amt Handled (lb ai)	107 ± 17 (n = 3)	108	116	121	90 to 124
Biological Monitoring (μg/kg)	7.8 ± 10 (n = 3)	2.1	11	16	2.1 to 20

Passive Dosimetry -- Total absorbed (3% dermal and 100% inhalation oral equivalent) dose (μg/kg)	9.6 ± 16 (n = 3)	1.0	14	22	0.2 to 28

Applicator - Groundboom Open Cab					
Amt Handled (lb ai)	57.6 ± 39.8	36	90	111	21 to 124
Biological Monitoring (μg/kg)	2.1 ± 1.5	2.2	2.5	4.2	0.4 to 4.7
Passive Dosimetry -- Total absorbed (3% dermal and 100% inhalation oral equivalent) dose (μg/kg)	2.0 ± 1.4	1.7	3.4	3.7	0.61 to 4.1

Body weight from test subjects for both biomonitoring and passive dosimetry were used for comparison. A mean penetration factor from these replicates was used to estimate exposure under the coveralls. Note: These penetration factors are based on this specific study with new clothing, the values are not representative of HED's policy on protection factors.

- **MRID No. - 431381-02.** Honeycutt, R.C. & Day, E.W. Jr. 1994. Evaluation of the potential exposure of workers to Chlorpyrifos during mixing and loading, spray application, and clean-up procedures during the treatment of citrus groves with Lorsban 4E insecticide.

Passive dosimetry (dermal and inhalation) and biological monitoring samples (urine analysis) were collected for 15 open pour liquid mixer/loader replicates and 15 open cab airblast applicator replicates. The applications were made to citrus groves (i.e., lemons and oranges) at the maximum label rate of 6 lb ai/acre. To summarize, the study meets the acceptability criteria outlined in Subdivision U of the Pesticide Assessment Guidelines. The quality control/quality assurance aspects of the passive dosimetry were adequate for the dermal whole-body dosimeters and inhalation canisters; however, the field recovery results for the hand rinses are questionable (i.e., 131 percent). The quality control/quality assurance aspects of the biological monitoring were sufficient. The data from this study are of sufficient scientific quality to be used in the assessment.

	Mean ± std	Median	75^{th}%tile	90^{th}%tile	Range
Mixer/Loader - Open mixing/loading					
Amt Handled (lb ai)	78 ± 22 (n = 15)	82	89	89	45 to 134
Biological Monitoring (μg/kg)	10 ± 21 (n = 15)	4.4	8.1	13	1 to 85
Passive Dosimetry -- Total absorbed (3% dermal and 90% PF for the inhalation for the respirator) dose (μg/kg)	6.2 ± 6.2 (n = 15)	4.5	7.5	11	0.67 to 26

Applicator - Open Cab					
Amt Handled (lb ai)	78 ± 22 (n = 15)	82	89	89	45 to 134
Biological Monitoring (μg/kg)	13 ± 24	4.8	9.6	29	1.4 to 95
Passive Dosimetry -- Total absorbed (3% dermal and 90% PF for the inhalation for the respirator) dose (μg/kg)	5.9 ± 6.0	2.8	9.4	13	0.73 to 20

Body weight from test subjects for both biomonitoring and passive dosimetry were used for comparison. A mean penetration factor from these replicates was used to estimate exposure under the coveralls. Note: These penetration factors are based on this specific study with new clothing, the values are not representative of HED's policy on protection factors.

- **MRID No. - 444835-01.** R. F. Bischoff 1998. Evaluation of Chlorpyrifos exposure to workers during loading and application of Lorsban 15 % granular insecticide during corn planting.

Passive dosimetry (dermal and inhalation) and biological (urine) monitoring samples were collected for 16 combined replicates of loading and applying Lorsban 15G during corn planting. The test subjects loaded the granular product in row planters (8 to 12 row planters) and accompanied the tractor driver (i.e., farmer) in the enclosed cab. The "simulated" applicator portion of the replicate does not appear to introduce any significant uncertainties in the results. Four of the replicates were monitored in Kentucky and the other 12 replicates were in Michigan. Lorsban 15G was applied at the typical rate of 8 oz./1,000 linear feet, however, the row spacing was not reported (depending on the row spacing the rate is equivalent to 0.975 to 2.175 lb ai/A using 40 to 18 inch rows, respectively). Furthermore, the number of acres planted per replicate were not reported. The maximum rate (Reg. No. 62719-34) is 16 oz/1,000 linear feet which at an 18 inch row spacing would correspond to 4.35 lb ai/A. However, there is a use restriction on the Lorsban 15G label of a maximum of 13.5 pounds of product per acre for corn (i.e., 2 lb ai/A). Although the application rate in lb ai/acre could not be determined, it is not the maximum rate on the label. Replicates ranged from 2.6 to 5.9 hours. Dermal exposure was monitored using whole body dosimeters (total deposition) and T-shirts and briefs worn underneath the whole body dosimeters to measure penetration. Hand washes were used to monitor potential hand exposure. Inhalation exposure was monitored using personal air sampling pumps along with a sampling train consisting of cellulose ester filters with a Chromosorb 102 solid sorbent. Biomonitoring consisted of urine specimens collected at 12-hour intervals over a six day period. The urine was analyzed for 3,5,6-trichloropyridinol (TCP), the principal metabolite of chlorpyrifos in humans. Urinary creatinine was also measured to evaluate the completeness of each urine collection. The QA/QC aspects (e.g., field recoveries) were adequate. To summarize, the study meets the acceptability criteria outlined in Series 875 Group A (except the maximum rate was not used) and the results of the study are used in the risk assessment. The monitoring data from the study are presented in the table below for a comparison of the passive dosimetry to the absorbed dose. These results were not used in the risk assessment "as is" because the study design was not representative of the maximum labeled rates and only monitored for a partial day. Therefore, the data in the risk assessment were extrapolated to represent the amount of chlorpyrifos that may be handled in a day.

	Mean ± std	Median	75^{th}%tile	90^{th}%tile	Range
Amt Handled (lb ai)	77.8 ± 21 (n = 16)	82	89.4	89.4	44.7 to 134
Biological Monitoring (μg/kg)	0.73 ± 0.33 (n = 12)	0.71	0.96	1.04	0.13 to 1.39
Passive Dosimetry **--** Total absorbed (3% dermal and 100% inhalation oral equivalent) dose (μg/kg)	0.3 ± 0.36 (n = 16)	0.14	0.31	0.65	0.056 to 1.4

Body weight from test subjects for both biomonitoring and passive dosimetry were used for comparison. Baseline absorbed dose levels at the same level after application (i.e., potentially ND from application activity) were excluded because of high baseline values. A mean of 3.36% penetration (range 0.74% to 7.3%) was used to estimate exposure under the coveralls. Note: These penetration factors are based on this specific study with new clothing, the values are not representative of HED's policy on protection factors.

- **MRID No. - 447393-02.** Knuteson et. al. 1999. Evaluation of Potential Exposure to Workers Mixing and Loading Lorsban-4E Insecticide Products for Aerial Application.

Exposures were estimated based on both passive dosimetry measurements and biomonitoring of urinary 3,5,6-trichloro-2-pyridinol (TCP) (the primary metabolite of chlorpyrifos). This study characterizes exposures to 14 workers during the mixing and loading of Lorsban-4E or Lorsban 4E-SG, a 45 percent emulsifiable concentration insecticide for aerial application to cotton, alfalfa and wheat. Each worker mixed and loaded enough product to cover a 500 acre per day target rate (170 to 250 lb ai and 42.5 to 62.5 gallons product for wheat and 500 lbs ai and 125 gallons of product for cotton and alfalfa). Lorsban was applied at the maximum label registered application rates of 0.5 lb active ingredient (ai) per acre for wheat, and 1.0 lb ai per acre for cotton and alfalfa. The study examined exposures to a total of 15 workers, five for wheat in Dalhart, Texas, five for cotton in Gila Bend, Arizona and five for alfalfa in Gila Bend, Arizona. The mixing/loading exposure period ranged from 40 to 131 minutes, with an average of 89 minutes. The workers wore cotton overalls, a cotton T-shirt, brief, and socks, chemical resistant gloves, apron and knee-high boots, goggles and a hat during the mixing/ loading operation. The total absorbed doses estimated from biomonitoring ranged from 0 to 32 µg/kg BW, with an arithmetic mean of 3.61 ± 8.26 µg/kg BW, and a geometric mean of 1.32 µg/kg BW. The arithmetic mean values from the biomonitoring are three times higher than the arithmetic estimates from dosimetry. Baseline (i.e., background) chlorpyrifos exposures ranged from 0.13 to 4.55 µg/kg with a mean of 1.13 µg/kg, despite the fact that workers were instructed to avoid chlorpyrifos exposure 10 days prior to the study initiation. A summary of the study results are provided below. The majority of the exposure data meet the criteria specified in Series 875 Group A. Only minor issues were identified. The study evaluated 15 workers, however one of the workers (ML13) dropped out of the study the day after exposure, and therefore was not included in the biomonitoring results.

	Mean±std	Median	75th%tile	90th%tile	Range
Amt Handled (lb ai)	411± 131 (n = 15)	500	500	500	170 to 500
Biological Monitoring (μg/kg)	3.9 ± 8.5 (n = 13)	1.8	2.7	3.7	0.2 to 32
Passive Dosimetry - Total absorbed (3% dermal and 100% inhalation oral equivalent) dose (μg/kg)	1.1 ± 0.60 (n = 15)	0.91	1.1	2.1	0.83 to 2.54

Body weight from test subjects for both biomonitoring and passive dosimetry used for comparison. A 16.7% penetration was used to estimate exposure under the coveralls and aprons based on the "greatest average penetration found in torso front plus 1 standard deviation".

In addition to these handler studies, three additional registrant-generated risk assessments were submitted using the collected data. The risk assessments are summarized below. As noted below, the results of these assessments are not used in the Agency's risk assessment.

- **MRID No. - 430420-02.** Chlorpyrifos: an exposure and risk assessment for workers/loading and applying Empire 20 insecticide to ornamentals in greenhouses.

This study is a risk assessment generated by the registrant based on the data submitted in MRID No.430279-01. In the original exposure monitoring study cited in the registrant-generated assessment, Empire 20 was monitored during mixing/loading and applying chlorpyrifos to ornamental plants in a greenhouse. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposures as well as total absorbed dose. The registrant-generated assessment is based on toxicity endpoints (NOAELs) of plasma cholinesterase inhibition from an oral human study using NOAELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The registrant-generated assessment included calculations of margins of safety and a Monte Carlo simulation. The registrant concluded that the probability for any of these workers to exceed the single or multiple NOAEL of chlorpyrifos is very small, and that this is confirmed by the absence of significant cholinesterase depression in the test subjects on the day after application. The application techniques (i.e., low pressure handwand, backpack, and high pressure handwand) were combined in the assessment because the registrant determined that there was no significant difference between exposures for test subjects applying to plants overhead versus plants on the bench or floor. The Agency is concerned with combining the low pressure handwands with the high pressure handwands along with the inconsistent use of protective clothing (e.g., some test subjects wore rainwear, respirators, and/or face shields). Furthermore, the Agency does not regulate at the NOAEL but rather at doses lower than the NOAEL based on uncertainty factors (e.g., 10x for intra-species and 10x for inter-species variations). Therefore, the Agency used the raw data combined with other surrogate data to perform its own deterministic assessment.

- **MRID No. - 431381-01.** Chlorpyrifos: an exposure and risk assessment of workers associated with airblast sprayer application of Lorsban 4E to high crops.

This study is a risk assessment generated by the registrant based on the data submitted in MRID No.431381-02. In the original exposure monitoring study cited in the registrant-generated assessment, LORSBAN 4E was monitored during mixing/loading and airblast application. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposures as well as total absorbed dose. Only the biological monitoring data were used in the registrant-generated assessment. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOAELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The registrant concluded that the probability for any of these workers to exceed the single or multiple NOAEL of chlorpyrifos is very small, and that this is confirmed by the absence of significant cholinesterase depression in the test subjects on the day after application. However, the Agency does not regulate at the NOAEL but rather at doses lower than the NOAEL based on uncertainty factors (e.g., 10x for intra-species and 10x for inter-species variations). Therefore, the Agency used the data to perform its own risk assessment.

- **MRID No. - 429944-01.** Chlorpyrifos: an exposure and risk assessment of workers associated with mixing/loading, application and reentry following ground boom application to low crops.

This study is a risk assessment generated by the registrant based on the data submitted in MRID No. 429745-01. In the original exposure monitoring study cited in the registrant-generated assessment, LORSBAN 4E and LORSBAN 50W were monitored during mixing/loading, groundboom application, and reentry scouts. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposures as well as total absorbed dose. Only the biological monitoring data were used in the registrant-generated assessment. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOAELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The results <u>as reported</u> in the registrant-generated assessment, based on a Student t-test statistical analysis, are as follows: (1) there is a finite probability (24.2%) for an individual who repeatedly mixes and loads LORSBAN 50W to exceed the NOAEL for multiple exposures to chlorpyrifos, and (2) there is a finite probability (1.06%) for an individual who repeatedly applies (groundboom) LORSBAN to exceed the NOAEL for multiple exposures to chlorpyrifos. However, the Agency does not regulate at the NOAEL but rather at doses lower than the NOAEL based on uncertainty factors (e.g., 10x for intra-species and 10x for inter-species variations). Therefore, the Agency used the data to perform its own risk assessment.

2.1.2 Determination of Occupational Handler Exposures

The above chemical-specific exposure data are used by the Agency to assess the potential handler exposures to chlorpyrifos. However, of the five monitoring studies submitted by DAS, only two of the studies measured at least 15 replicates (minimum as per the Pesticide Assessment Guideline criteria) of a specific activity (one measuring 15 replicates of both mixer/loader and airblast applicators, the other study measuring 16 replicates of a combined mixer/loader/applicator for a granular formulation). As for the other three studies, one study measured 13 replicates of an applicator applying with various types of high pressure handwands in a greenhouse, 1 replicate of a low pressure handwand, and 2 replicates of a backpack sprayer; the second study measured 9 replicates of an open cab groundboom applicator, 6 replicates of an open mixing/loading EC formulation, and 3 replicates of an open bag WP formulation (open bag WP formulation no longer supported by DAS); and the final study measured 14 replicates of an open mixing/loading of liquids for aerial applicators. Therefore, three of the five DAS studies contain an insufficient number of replicates (as specified by Subdivision U Guidelines) to support the exposure scenarios. Moreover, the total of five studies submitted by DAS in support of the chlorpyrifos reregistration do not encompass all of the uses of the chemical on the labels nor do they all provide sufficient mitigation (e.g., PPE or engineering controls) to meet the target MOE of 100. PHED V1.1 was available to supplement the chemical-specific data and to assess the exposure scenarios which were not monitored by DAS. HED's policy is to supplement chemical-specific data with available surrogate data in PHED to increase the sample size (U.S. EPA/HC 1995a - PHED V1.1 Evaluation Guidance). This policy is in effect because individual chemical-specific studies, even when fulfilling the Guideline minimum number of replicates, do not necessarily encompass the variety of equipment in use throughout the country and the large variability of exposures among handlers.

While data from PHED provide the best available information on handler exposures, it should be noted that some aspects of the included studies (e.g., duration, acres treated, pounds of active ingredient handled) may not accurately represent labeled uses in all cases. PHED was designed by a Task Force of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide Regulation, and member companies of the American Crop Protection Association. PHED is a software system consisting of two parts -- a database of measured exposure values for workers involved in the handling of pesticides under actual field conditions and a set of computer algorithms used to subset and statistically summarize the selected data. Currently, the database contains values for over 1,700 monitored individuals (i.e., replicates).

The data in PHED are graded by analytical results only, not study design. The system was designed in this fashion so that the users could select specific criteria to subset the PHED database to reflect the exposure scenario being evaluated (Leighton 1995). The subsetting algorithms in PHED are based on the central assumption that the magnitude of handler exposures to pesticides are primarily a function of activity (e.g., mixing/loading, applying), formulation type (e.g., wettable powders, granulars), application method (e.g., aerial, groundboom), and clothing scenarios (e.g., gloves, double layer clothing). Once the data for a given exposure scenario has been selected, the data are normalized (i.e., divided by) by the amount of pesticide handled resulting in standard unit exposures (milligrams of exposure per pound of active ingredient handled). Following normalization, the data are statistically summarized. The distribution of exposure values for each body part (e.g., chest, upper arm) is categorized as normal, lognormal, or “other” (i.e., neither normal nor lognormal). A central tendency value is then selected from the distribution of the exposure values for each body part. These values are the arithmetic mean for normal distributions, the geometric mean for lognormal distributions, and the median for all “other” distributions. Once selected, the central tendency values for each body part are composited into a “best fit” exposure value representing the entire body.

Table 3 presents the exposure scenarios, application rates, and area (i.e., acres or gallons) potentially treated that have been used in the exposure calculations. Chlorpyrifos labels include a multitude of uses and a wide range of application rates. Therefore, the rates presented in Table 3 are not all inclusive and an attempt has been made to assess the higher application rates to ensure that the exposures are not underestimated if applied up to the labeled maximum rates. Once the Agency reviews the Mar Quest survey, additional application rates may be added to the assessment to better characterize the exposures for risk management decisions where warranted.

The results of the passive dosimetry and biological monitoring data are presented in Appendix A. The calculations for the short-term occupational assessment are provided in the appendix. Only the short-term assessment is summarized in this chapter because the uses of chlorpyrifos are believed to be best represented by the short-term duration of one month or less of continuous use by agricultural applicators. Although there may be a few individuals who apply chlorpyrifos daily for more than a month, those individuals will represent a very small segment of the overall users and most likely those limited individuals would not handle on a daily basis the amount of chlorpyrifos estimated in this assessment. The dermal absorption rate was not used for the short-term assessment because the short-term toxicological endpoint is derived from a dermal study. For the biological monitoring results, the NOAEL from the 21-day dermal study was multiplied by the 3 percent dermal absorption factor to estimate the oral equivalent NOAEL in the rat (i.e., NOAEL of 5 mg/kg/day x 0.03 = NOAEL of 0.15 mg/kg/day). The results of the short-term MOEs are presented in a summary table (see Table 4).

Table 3: Exposure Variables for Agricultural Uses of Chlorpyrifos.

Exposure Scenario (Scenario #)	Are Biological Monitoring Data Available? [a]	Application Rates (lb ai/acre)[b]	Daily Acres Treated[c]
Mixer/Loader Exposure			
Mixing/Loading Liquids for Aerial and/or Chemigation Application (1a)	Yes - 14 reps (447393-02)	1.5 cranberries, corn (most crops at 1 lb ai/acre)	350
		3.5 citrus[d]	100
Mixing/Loading Liquids for Groundboom Application (1b)	Yes - 3 reps (429745-01)	1.5 predominant max / 5.0 tobacco max for nematodes in NC & SC	80
		2 & 4 sodfarm(2 lb ai/A rate also for tobacco and potatoes)	80
		8.0 sodfarm fire ants (harvest only)	10
Mixing/Loading Liquids for Airblast Application (1c)	Yes - 15 reps (431381-02)	2.0 predominant max such as Fruits & Nuts	40
		6.0 citrus (high dilution rate)	20
Mixing WP for Aerial Application (2a)	No	2.0 predominant max (orchards)	350
		3.5 citrus[d]	100
Mixing WP for Groundboom Application (2b)	Yes - 6 reps (429745-01, open bag only, no longer supported by DAS)	1.0 predominant max (brassica)	80
		4.0 soil treatment ornamentals outdoors / 1.3 & 3.0 sodfarm	80
		8.0 sodfarm fire ants (harvest only)	10
Mixing WP for Airblast Application (2c)	No	2.0 predominant max (orchards)	40
		6.0 citrus (high dilution rate)	20
Loading Granulars for Aerial Application (3a)	No	1.95 maximum aerial rate	350
Loading Granulars for Ground Application (3b)	Yes - 16 reps (3a & 7 combined 444835-01)	1.0 typical corn / 2.0 max corn / 3.0 maximum ground rate (tobacco)	80 (corn at plant)
Applicator Exposure			
Aerial (Spray) -- Enclosed Cockpit (4a)	No	2.0 orchards (most crops at 1 lb ai/acre)	350
		3.5 citrus[d]	100
Aerial (Granulars) -- Enclosed Cockpit (4b)	No	1.95 max aerial rate	350
Groundboom Tractor (5)	Yes - 9 reps (429745-01)	1.5 predominant max / 5.0 tobacco max	80
		4 sodfarm	80
		8.0 sodfarm fire ants	10
Airblast Applicator (6)	Yes - 15 reps (431381-02)	2.0 predominant max (orchards)	40
		6.0 citrus (high dilution rate)	20

Exposure Scenario (Scenario #)	Are Biological Monitoring Data Available? [a]	Application Rates (lb ai/acre)[b]	Daily Acres Treated[c]
Tractor-Drawn Granular Spreader (7)	Yes -see #3b (3b & 7 combined 444835-01)	1.0 typical corn / 2.0 max corn / 3.0 maximum ground rate (tobacco)	80 (corn at plant)
Seed Treatment (8)	No	No Data	No Data
Dip Application (Preplant Peaches) (9)	No	No Data	No Data
Flagger Exposure			
Spray Applications (10)	No	2.0 predominant max	350
		3.5 citrus[d]	100
Granular Applications (11)	No	1.95	350
Mixer/Loader/Applicator Exposure			
Backpack Sprayer (12)	Yes - 2 reps (430279-01)	0.0417 lb ai/gal predominant max / 0.08 lb ai/gal bark beetle treatment / 0.03 lb ai/gal stump treatment	40 gal/day
		3.5 citrus bark	1 A/day
		0.039 lb ai/gallon/750ft^2 animal premise fly treatment	1,000 ft^2
Low Pressure Handwand (13)	Yes - 1 rep (430279-01)	0.0417 predominant max / 0.08 lb ai/gal bark beetle treatment / 0.03 lb ai/gal stump treatment	40 gal/day
		3.5 citrus bark	1 A/day
		0.039 lb ai/gallon/750ft^2 animal premise fly treatment	1,000 ft^2
High Pressure Handwand (greenhouse uses) (14)	Yes - 13 reps (430279-01)	Min. 0.0033 lb ai/gal	1000 gal/day
		Max. 0.0066 lb ai/gal	
Hydraulic Hand-held Sprayer for Bark/Pine Seedling Treatment (15)	No	3.5 citrus bark	10
		0.08 lb ai/gal bark beetle treatment / 0.16 lb ai/ gal pine seedling treatment	1,000
		0.039 lb ai/gallon/750ft^2 animal premise fly treatment	10,000 ft^2
Dry Bulk Fertilizer Impregnation (16)	No	1.0 lb ai / 200 lb fertilizer / acre	No Data

[a]Biological monitoring data are available from several chemical-specific studies (discussed in the text above) and these data are presented in Appendix A Table A4. Although biological monitoring scenarios are available for some of the scenarios as indicated in this table, passive dosimetry data are presented for comparison because insufficient replicates and/or additional risk mitigation measures were necessary. The biological monitoring studies also contain partial replicates of passive dosimetry.

[b]Application rates are the maximum labeled rates found on EPA Reg. Nos. 62719-38, -221, -245, -34; -79, -72, -166, -220, 34704-66 (Clean Crop Chlorpyrifos 4E -- sodfarm fire ant rate), 499-367 (499-367 is the only greenhouse label identified),

and 10350-22 for animal premise treatments. **"Predominant max"** in this table refers to the most **frequently identified maximum** application rate found on the labels for the specific formulation and equipment type. Typical rates are also included to characterize the chlorpyrifos uses. Not all application rates are included for all crops, instead, a cross-section of rates are used to represent the uses of chlorpyrifos.

[c]Daily acres treated are based on HED's estimates of acreage (or gallonage) that would be reasonably expected to be treated in a single day for each exposure scenario of concern. The sodfarm fire ant rate is restricted on the label for harvest only, therefore, this rate is limited to the amount of sod that may be harvested in a reasonable time frame. Therefore, using the limited data available, approximately 10 acres treated per day are assumed to be the upper range . The median value of <1 acre was not included because the target MOE was reached at the high end.

[d]The application rates on the Lorsban 4E (EPA Reg. No. 62719-220) and 50W (EPA Reg. No. 62719-39 discontinued as of 1995 and sold as -221) labels indicate that for citrus at the 6.0 lb ai/A rate it is necessary to use 100 to 2,400 gallons per acre dilute spray. Therefore, this rate is not expected to be feasible for an aerial applicator. The label language should be clarified so that the 6.0 lb ai/A rate is for ground only. Additionally, citrus orchards are believed to be relatively small plots and 100 acres per day is assumed in the assessment for aerial applications.

2.1.3 Summary of Uncertainties

The handler exposure assessments encompass all of the major uses of chlorpyrifos throughout the country. The assessment provides the estimated exposures for the maximum labeled rates. In addition to providing exposure estimates for those individuals who use the maximum rates stipulated on the labels, the Agency also includes other rates that may be most predominately used to assist the regulatory risk managers in their decisions. However, it is difficult to assess all of the "typical" agricultural uses (i.e., actual or predominant application rates -- "predominant" being defined as the most frequently found rates on labels). DAS recently submitted a use survey (i.e., Mar Quest research study) to assist the Agency in determining how chlorpyrifos is used in the field. However, at the time that this chapter was developed, the Mar Quest study had just been received and its scope has not been reviewed. Once reviewed, the Agency will incorporate the appropriate information from this survey to better characterize chlorpyrifos risks for the Agency's risk managers. In the mean time, an assessment has been developed which is believed to be realistic and yet provides a reasonable certainty that the exposures are not underestimated. The assumptions and uncertainties identified below are included for characterization and transparency:

- *Application Rates:* Each exposure scenario includes the allowable maximum application rate that was identified on the available product labels. In addition, a range of application rates was used when the maximum application rates for various crops varied widely or when specific rates were requested by DAS to better characterize the scenario. The "predominant max" rate that is assessed is defined as the most frequently found maximum application rate on the labels for the specific equipment type and formulation. Identifying the most frequently found maximum labeled application rate was accomplished by reviewing the product labels. Other than a national survey, there are no statistical techniques to determine what rates to include in an assessment -- other than always including the maximum rates. Therefore, DAS has requested that the Agency also include the actual rates identified in the Mar Quest research study for further demarcation of the risks. The Agency will further characterize the uses once the study is reviewed. In most instances, the maximum labeled application rates were applied to application techniques that are feasible given the amount of dilute spray that needs to be applied. For example, the citrus aerial maximum application rate is assessed at 3.5 lb ai/acre. The maximum citrus rate (i.e., 6 lb ai/A) requires a high volume of dilute spray (i.e., 100 to 2,400 gallons) which would not be practical in an aircraft. Moreover, the high dilution rate would also limit airblast acreage treated to 20 acres per day. The labels should be clarified to reflect the maximum rate of 3.5 lb ai/acre for aerial application to citrus.

- *Amount Handled:* The daily acres treated are HED standard values (see Table 3) along with the amount of gallons that may be applied using handheld equipment. If the Mar Quest survey recently submitted by DAS provides reliable chemical-specific information on acreage treated, the Agency will revise these standard values using the high end of these distributions. The high end of the distributions would be used in the deterministic approach because of the small sample sizes and using *a mix of high end and central values is probably the best way to create a reasonable high end scenario* (USEPA 1992b). In this deterministic approach, central tendency values for unit exposures from PHED are mixed with high end input parameters such as the application rate and acres treated. Deviations from the HED standard values include the aerial acreage for citrus and the groundboom acreage for the sodfarm fire ant application rate. The citrus acreage is assessed at 100 acres because citrus orchards are generally grown in smaller plots. As for the sodfarm assessment, the Turfgrass Producers International's (TPI) membership-wide survey, for production year 1997, states that the median sodfarm is 350 acres (of which 235 acres in turf) and the estimated daily harvest during the peak months is 0.82 acres (median). The sodfarm fire ant rate is assessed at 10 acres because this is believed to be a *reasonable maximum* area that can be harvested in a single day and/or the area a commercial applicator might apply to multiple sodfarms in a single day. The median area of 0.82 acres was not used in the calculations to further characterize the potential hazard because the target MOE was achieved at the 10 acres.

- *Unit Exposures:* The unit exposure values calculated by PHED generally range from the geometric mean to the median of the selected data set. To add consistency and quality control to the values produced from this system, the PHED Task Force has evaluated all data within the system and has developed a set of grading criteria to characterize the quality of the original study data. The assessment of data quality is based on the number of observations and the available quality control data. These evaluation criteria and the caveats specific to each exposure scenario are summarized in Appendix A Table A3 and the PHED Surrogate Exposure Guide dated August 1998. While data from PHED provides the best available information on handler exposures, it should be noted that some aspects of the included studies (e.g., duration, acres treated, pounds of active ingredient handled) may not accurately represent labeled uses in all cases.

- *Representativeness of Surrogate Data:* The majority of the application techniques from PHED are typical equipment types expected to be used for chlorpyrifos treatments. However, for scenario 15, a reel-type hose connected to a truck-mounted spray tank monitored for rights-of-way applications is the closest equipment-type available for assessing exposures for citrus and ornamental bark treatments.

- *Use of Biological Monitoring:* The biological monitoring results are reported as arithmetic means as a conservative measure of centrality and because of the small number of replicates, however, using the geometric means (assuming a lognormal dataset) would not affect the risk mitigation measures.

- *Exposure Factors:* The ratio of the body surface area used in dermal calculations to the body weight to estimate potential dose overestimates by a factor of 1.1. The ratio is not physiologically matched in that the surface area is for an average male while the body weight is the median for both male/female. The reduction factor would increase a dermal MOE from 8 to 9 or 90 to 100. HED has agreed to use the NAFTA recommended values for breathing rate rather than the existing rate in Series 875 Group A (i.e., previously known as Subdivision U). Series 875 Group A recommends an inhalation rate of 29 L/min. The new NAFTA recommended inhalation rates are 8.3, 16.7, and 26.7 L/min for sedentary activities (e.g., driving a tractor), light activities (e.g., flaggers and mixer/loaders < 50 lb containers), and moderate activities (e.g., loading > 50 lb containers, handheld equipment in hilly conditions), respectively. These inhalation reduction factors are 3.5 for tractor drivers, 1.7 for mixer/loaders and flaggers, and 1.1 for handheld equipment. These changes in exposure factors will be programmed in PHED V2.0 and are characterized in this document for regulatory risk management decisions.

2.1.4 Calculations of Exposure

The chlorpyrifos absorbed doses from the biological monitoring studies are estimated by dividing the amount of the metabolite 3,5,6-TCP excreted by the fraction 0.4. This factor of 4 represents the ratio of the molecular weights of 3,5,6-TCP (198) and chlorpyrifos (350.6) (i.e., 198/350.6 = 0.56) and the fraction of the absorbed chloripyrifos dose expected to be excreted in the urine (0.72). The fraction expected to be excreted in the urine is based on a human study in which an average of 72 percent of orally administered chlorpyrifos was excreted in the urine as 3,5,6-TCP (Nolan et al. 1982).

The algorithms to calculate the inhalation and dermal unit exposures from passive dosimetry studies are numerous and the readers are referred to Series 875 Group A (formerly the U.S. EPA Pesticide Assessment Guidelines, Subdivision U: Applicator Exposure) and the PHED Reference Manual (U.S.EPA et al. 1995b) for specific algorithms and body surface areas. HED's current RED format does not include sample calculations for the unit exposures (e.g., mg/lb ai), but examples can be found in the PHED Reference Manual. However, potential daily dermal exposure (e.g., mg/day) is calculated using the formula below. The short-term exposures do not incorporate the dermal absorption estimate because the endpoint is derived from a 21-day dermal rat study. No correction factors are used for relative differences in rat versus human skin permeability or differences in metabolism.

$$Daily\ Dermal\ Exposure\left(\frac{mg\ AI}{Day}\right) = Dermal\ Unit\ Exposure\left(\frac{mg\ AI}{lb\ AI}\right)\cdot Max.\ Appl.\ Rate\left(\frac{lb\ AI}{Acre}\right)\cdot Max.\ Area\ Treated\left(\frac{Acres}{Day}\right)$$

Potential daily inhalation exposure is calculated using the following formula:

$$Daily\ Inhal.\ Exposure\left(\frac{mg\ AI}{Day}\right) = Inhal.\ Unit\ Exposure\left(\frac{mg\ AI}{lb\ AI}\right)\cdot Max.\ Appl.\ Rate\left(\frac{lb\ AI}{Acre}\right)\cdot Max.\ Area\ Treated\left(\frac{Acres}{Day}\right)$$

These calculations of potential daily exposure to chlorpyrifos by handlers are used to calculate the absorbed doses and total risk to those handlers.

2.2 Risk Characterization

The handler risks are characterized using a hazard evaluation approach. In addition to the numeric estimates, a discussion of the estimates is also included in the sections below. Using the potential exposure scenarios identified in the exposure section above, the Agency estimated the potential risk to persons from handler exposure to chlorpyrifos using the following equations.

Daily Short-term Potential Dermal Dose (mg/kg/day) is calculated as:

$$\frac{\text{Daily PotentialDermal Exposure (mg/day)} * 1 \text{ (dermal absorptionfactor)}}{\text{Body Weight (kg)}}$$

Daily Short-term Inhalation Dose (mg/kg/day) is calculated as:

$$\frac{\text{Daily Inhalation Exposure (mg/day)} * 1 \text{ (inhalation absorptionfactor)}}{\text{Body Weight (kg)}}$$

Margin of Exposure (MOE) is calculated by dividing the NOAEL by the daily dose.

$$\text{Short-term Duration Exposure MOE} = \frac{\text{NOAEL of 5 mg/kg/day 21-day dermal study}}{\text{Daily Potential Handler Dose (mg/kg/day)}}$$

A Total MOE is also calculated because there is a common endpoint (i.e., ChEI). The uncertainty factor of 100 is applied to all routes of exposure. Route specific data are available for the dermal and inhalation routes, and therefore, the following reciprocal MOE calculation is used:

Total MOE = 1/((1/Dermal MOE) + (1/Inhalation MOE))

2.2.1 Determination of Risk From Handler Exposures

A risk assessment in the form of "margins of exposure (MOEs)" were calculated for handlers for the short-term (1 to 30 days) duration. The MOE is the ratio of the dose that was shown to cause a no adverse effect level (NOAEL) in the animal to the anticipated handler exposure. The ratio, or MOE, of 100 signifies that the dose level in the animal that caused no effects is 100 times the dose level estimated for the handler. A target MOE of 100 is used to account for 10x variability between animals and humans and another 10x to account for the variability among humans. Appendix A presents the MOE calculations for personal protective equipment (PPE) and engineering controls using the absorbed doses from the biological monitoring and passive dosimetry results from the chemical-specific studies combined with surrogate data from PHED for the agricultural and greenhouse uses of chlorpyrifos. As described in the *Handlers Exposure & Assumptions* section (see Section 2.1.2), the intermediate-term assessment is not provided because it is believed that the appropriate duration of exposure for the majority of agricultural handers at the amounts of chlorpyrifos assessed is less than 30 days (i.e., short-term). Appendix A, Tables A1 and A2, present the short-term PPE and engineering control assessments, respectively. Table A3 presents the passive dosimetry scenario descriptions of data confidence for the agricultural, ornamental, and greenhouse uses of chlorpyrifos. Finally, Table A4 presents the short-term assessment using the biological monitoring results from the chemical-specific studies.

The biological monitoring results were also compared to the short-term endpoint. Because the short-term endpoint is derived from a 21-day dermal study, it is necessary to convert the dermal NOAEL to an oral equivalent. The 21-day dermal NOAEL of 5 mg/kg/day multiplied by 3 percent dermal absorption yields an equivalent oral NOAEL of 0.15 mg/kg/day. Absorbed doses from biological monitoring studies are available for mixing/loading liquids for groundboom (n = 3) and airblast equipment (n = 15), mixing/loading open bag wettable powder formulation (no longer supported by DAS) for groundboom equipment (n = 6), applying chlorpyrifos using groundboom (n = 9) and airblast applicators (n = 15), mixing/loading/applying (MLA) for tractor-drawn granular spreader (n = 16), and a low pressure handwand (n = 1), backpack (n = 2), and high pressure handwand (n = 13) for uses in greenhouses.

Biological monitoring reflects the absorbed doses received by the test subjects, however, these data were not used exclusively to assess the risks because of either the need for additional risk mitigation measures (i.e., MOEs below the target of 100) or an insufficient number of replicates monitored. In fact, the MOEs are less than 100 for all but two (two additional MOEs of 94) of the short-term biological monitoring scenarios at the level of clothing worn by the test subjects. The biomonitoring results (reported as the arithmetic mean because of the small sample size) and the passive dosimetry results (reported as the "best fit" mean) are not directly comparable because of the different measures of centrality and the differences in PPE worn by the test subjects. However, the biological monitoring data support the overall assessment of risk mitigation selected (i.e., engineering controls often required if feasible) for chlorpyrifos.

Protection factors (PF) were not applied to the biomonitoring data to extrapolate to engineering controls because of the PPE worn by the test subjects in the studies. The test subjects in these studies wore various levels of PPE including coveralls over short-sleeved shirt, long-pants, T-shirt, chemical resistant gloves, aprons, respirators. The Worker Protection Standards (WPS) allows the handler to remove the PPE when using closed systems. The reduction in the exposure estimate would be on paper only and would not be representative of what is allowable in actual field conditions under the WPS labeling. Furthermore, HED's policy is to use empirically derived data, if available, prior to using estimated PFs.

HED calculated the passive dosimetry portion of the exposure estimates for the PPE MOEs using the following additional **PPE** assumptions:

- all occupational handlers are wearing footwear (socks plus shoes or boots), foot exposure is not traditionally monitored, and therefore, a 100 percent protection factor is implied;

- occupational mixers and loaders using open mixing techniques are wearing chemical-resistant gloves plus coveralls worn over long-sleeved shirts and long pants;

- occupational applicators who use open cab airblast or tractor-driven application equipment and handlers flagging for aerial applications are wearing chemical-resistant gloves (except flaggers -- no gloves) plus coveralls worn over long-sleeved shirts and long pants; and

- occupational handlers who use low pressure handwands are wearing chemical-resistant gloves plus coveralls worn over long-sleeve shirts and long pants.

- Also, if necessary, a dust/mist mask represented by a 5-fold protection factor is added to mitigate the risks.

If the PPE total MOE was 100 or greater (the NOAEL is based on data from animal studies, and therefore, a 10x is applied for inter-species and a 10x for intra-species variations) for an exposure scenario, then no further calculations were made. **In fact, some scenarios are sufficiently above 100 that the coveralls and/or respirators may be removed during the risk mitigation phase of the RED process.** If the PPE total MOE remained less than 100 for any occupational exposure scenario, an additional MOE was calculated based on mandatory use of engineering controls where feasible. Engineering controls are not available for occupational handlers (mixers, loaders, and applicators) who use hand-held application equipment. HED calculated the engineering-control MOEs for each occupational exposure scenario with a PPE total MOE of less than 100, using the following **engineering control** assumptions:

- all occupational handlers are wearing footwear (socks plus shoes or boots), foot exposure is not traditionally monitored, and therefore, a 100 percent protection factor is implied;;

- occupational mixers and loaders handling liquid formulations using a closed system are wearing chemical-resistant gloves plus long-sleeved shirts and long pants;

- occupational mixers and loaders handling wettable powders using a closed system (water-soluble packages) are wearing long-sleeved shirts and long pants, and chemical-resistant gloves; and

- occupational applicators who use aerial, airblast, or tractor-driven application equipment and handlers flagging for aerial applications are located in enclosed cabs or cockpits and are wearing long-sleeved shirts and long pants, and no gloves.

2.2.2 Summary of MOEs

This section attempts to summarize and explain the relevant outcomes of the calculated doses and MOEs so that they can be used by the risk managers for regulatory decisions. Table 4 and Appendix A report MOEs for the handler scenarios encompassing various formulations and equipment types. These results are further subdivided by application rates, area treated, and various levels of PPE and engineering controls. Finally, the results are also segregated by the monitoring methodologies (i.e., biological monitoring vs. passive dosimetry). A brief synopsis of the 56 iterations of potential exposures/MOEs that are presented in this chapter indicate the following:

- Total MOEs (i.e., dermal and inhalation combined) range from 6 to 10,000;
- 2 MOEs are estimated to be less than 10;
- 6 MOEs are between 10 and 50
- 9 MOEs are between 50 and 100; and
- 39 of the MOEs are greater than 100.

Of the 14 MOEs calculated using the biological monitoring results, only two reach the target MOE of 100 using PPE. The test subjects' absorbed dose levels indicate the need for additional risk mitigation measures such as closed systems for loading liquids and enclosed cabs for groundboom and airblast applicators.

The results and discussion for each of the 16 exposure scenarios are detailed below.

(1) Mixing/loading Liquids: There are three separate DAS biological monitoring studies for mixing/loading of liquids and multiple surrogate studies in PHED V1.1. The only study that monitored a daily representative amount of chlorpyrifos per replicate is the aerial mixer/loader study (MRID 447393-02). In contrast to PHED data, where only composite point estimates are available, this study allows for the Agency to select a point on the distribution. The study is based on open mixing with the use of PPE. The arithmetic mean, 75th percentile, and 90th percentile absorbed doses are 3.9, 2.7, and 3.7 μg/kg, respectively. (Arithmetic mean is greater than the 90th percentile because the maximum value was 32 μg/kg.) The corresponding MOEs are 38, 58, and 41, respectively. Although the Agency does not have a formal policy on what point of the distribution to regulate on, the endpoint is of a short-term duration and a high end value would be selected. This is similar to the Agency's policy on determining a high end estimate using surrogate data from PHED (i.e., central tendency unit exposure value combined with high end inputs for application rates and area treated). This study and the biological monitoring data from MRID 429745-01 and 431381-02 indicate that a closed mixing/loading system is necessary for liquids. The surrogate data (PHED V1.1) for closed mixing systems indicates a concern to the Agency based on aerial uses (total MOEs of 52 for corn and 78 for citrus), and groundboom uses for tobacco at the maximum rate and sodfarm at the 4 lb ai/acre rate. The correction factors, discussed in the uncertainties section above, for body surface area and inhalation rates would increase the total MOEs for corn from 52 to 65, for citrus from 78 to 88; for tobacco from 69 to 84; and for sodfarms from 86 to 110.

The assessment for this scenario is based on data that the Agency believes to be high confidence. The biological monitoring data in the DAS indicate that a closed mixing/loading system is necessary to meet the target MOE of 100. However, even when using the closed system, some of the MOEs remain of concern. The closed loading systems in PHED include different types of closed loading equipment from 6 studies. The equipment range from probe transfers to dry couplings. For scenarios that provide MOEs less than 100, label specification of dry coupling systems only, would further reduce the risk.

(2) Mixing/loading Wettable Powders: The open bag WP formulation is no longer supported by DAS. Therefore, the absorbed dose monitored in MRID 429745-01 using the open bag packaging are not summarized. MOEs are greater than 100 for most crops/rates based on water soluble packets using the limited data in PHED V1.1. However, 3 of the 9 total MOEs are below 100. Specifically, there are concerns for the mixer/loaders supporting the two highest aerial application rates and the groundboom 3 lb ai/acre sodfarm rate. [Note: MOEs for the 8 lb ai/acre sodfarm rate is above 100 because of the limited scope of its use (i.e., believed to be limited to 10 acres for fire ant control just prior to harvesting.)] The concerns for the aerial use are for both dermal and inhalation routes. Although the correction factors, discussed in the uncertainties above for body surface area and inhalation rates, would increase the MOEs, they would not reach the target (total MOEs are 23 for orchards and 46 for citrus). The sodfarm total MOE of 67 is derived from a dermal MOE of 150 and an inhalation MOE of 120. Although the two routes of exposure are not of concern by themselves, together they provide a sufficient total dose to be of concern. The correction factors would improve the total MOE from 67 to 91.

This scenario is of low confidence because both the surrogate data and the DAS study lack sufficient number of replicates to meet the guideline criteria. A biological monitoring study should be designed and conducted to better define this scenario. In the meantime, the MOEs are of concern for the mixer/loaders handling large amounts of product for the aerial uses.

(3) Loading Granulars: The biological monitoring study (MRID 444835-01) and the passive dosimetry data in PHED V1.1 both support the use for the typical and maximum rates for corn for handlers wearing PPE (i.e., MOEs are greater than 100 with PPE). The larger amounts of chlorpyrifos handled for aerial applications and the maximum tobacco rate require the use of closed loading systems (if feasible) to reach MOEs of 100.

The inhalation route is driving the total MOEs and risk mitigation measures (e.g., closed loading system) in this scenario. This is noteworthy because the inhalation toxicity endpoint is from a vapor study and the handlers are exposed to particulates. A new inhalation toxicological endpoint derived from an aerosol study could provide more insight to the proper risk mitigation measures.

(4) Aerial Applicators: The liquid spray scenario for citrus reaches the target MOE if restricted to enclosed cockpits (open cockpit data are not available). However, the larger amounts of chlorpyrifos handled for fruit & nut orchard spraying provides a total MOE of 60 (dermal MOE 100 and inhalation

MOE 150). The correction factors, for body surface area and inhalation rates, would increase the MOEs, but they would not reach the target. Likewise, the granular applications are also of concern. This scenario provides a total MOE of less than 10 strictly because of the inhalation component (dermal MOE 320 and inhalation MOE 8).

This scenario is of low confidence because the surrogate data lacks sufficient number of replicates to meet the guideline criteria. A biological monitoring study should be designed and conducted to better define this scenario. Surveys on acres treated by aerial application for citrus and fruit & nut orchards would also be beneficial to better characterize the risks. Additionally, a new inhalation toxicological endpoint derived from an aerosol study would provide more insight to the proper risk mitigation measures. In the meantime, the MOEs are of concern for the applicators applying large amounts of chlorpyrifos for orchards and for all of the granular aerial uses.

(5) Groundboom Applicators: The biological monitoring study (MRID 429745-01) and the passive dosimetry data in PHED V1.1 both support the need for enclosed cab tractors. Moreover, the absorbed dose from the *9 partial day* replicates in the DAS study monitored in open cabs averaged 0.99 μg/kg with a 90th percentile of 1.9 μg/kg (corresponding to MOEs of 150 and 79, respectively). Using the enclosed cab data for groundboom applicators in PHED V1.1, all of the crops/rates achieve the target MOE (total MOEs range from 120 to 610). If enclosed cab tractors are required for all uses, risk estimates do not exceed HED's level of concern.

(6) Airblast Applicators: The biological monitoring study (MRID 431381-02) and the passive dosimetry data in PHED V1.1 both support the need for enclosed cab tractors. Moreover, the *partial day* replicates in the DAS study for the *9 replicates* monitored in open cabs averaged 13 μg/kg with a 90th percentile of 29 μg/kg (corresponding to MOEs of 12 and 5, respectively). The enclosed cab data for airblast applicators in PHED V1.1 indicate that the only scenario of concern is for the citrus spraying at the 6.0 lb ai/acre rate. The citrus total MOE of 70 is derived from a dermal MOE of 150 and an inhalation MOE of 130. Although the two routes of exposure are not of concern by themselves, together they provide a sufficient total dose to be of concern. However, the correction factors for body surface area and inhalation rates would increase the total MOE from 70 to 120. If enclosed cab tractors are required for all uses, risk estimates do not exceed HED's level of concern.

(7) Tractor-Drawn Granular Spreader: The test subjects in the biological monitoring study (MRID 444835-01) were measured while performing the loading of the granules into the equipment and then applying while in an enclosed cab. The biological monitoring total MOEs (see Appendix A Table A4) for the typical and maximum rates for corn are 190 and 94, respectively. Conversely, the passive dosimetry data in PHED V1.1 support the use of open cab tractors with the applicators wearing PPE for all crops/rates (MOEs ranging from 90 to 270). The difference in the use of the open vs enclosed cab is attributed to the combined job function of loading/applying in the biological monitoring study versus only applying in the passive dosimetry studies. Because the acreage in the assessment is assumed to be limited to 80 acres "at plant" for corn and many handlers presumably would perform both functions, the use of the enclosed cab from the biological monitoring study is preferred. Additional information on the area treated at plant for corn and tobacco may impact the need for an enclosed cab.

(8 & 9) Seed Treatment and Dip Applications: No data available to assess the risk. Use information and exposure data should be required.

(10 & 11) Flagging Liquids and Granulars: The data in PHED V1.1 supports the use of engineering controls (i.e., flagging from a truck) for liquid sprays and PPE for granulars. Enclosed trucks should be required for all sprays and PPE for the flagging of granulars. According to USDA, flagging is no longer necessary in modern agriculture. Therefore, prohibition of flagging on the labels is another option for risk mitigation.

(12 & 13) Backpack and Low Pressure Handwands: The biological monitoring study (MRID 430279-01) did not provide enough replicates to be used for risk assessment (only 2 and 1 replicates, respectively). The limited data in PHED V1.1 for these scenarios provide sufficient total MOEs while wearing PPE except for the high rates for the bark beetle (0.08 lb ai/gallon) and citrus bark (3.5 lb ai/acre) treatments. These total MOEs are 58 and 53, respectively. The correction factors for surface area and inhalation rates would increase the MOEs but they would not reach the 100.

This scenario is low confidence because both the surrogate data and the DAS study lack sufficient number of replicates to meet the guideline criteria. A biological monitoring study should be designed and conducted to better define this scenario. In the meantime, the MOEs are of concern for the handling large amounts of chlorpyrifos for bark treatment in nurseries and citrus groves.

(14) High Pressure Handwand: The biological monitoring study (MRID 431381-02) indicates that the absorbed dose for the *13 partial day* replicates in the DAS averaged 1.2 μg/kg with a 90th percentile of 2.1 μg/kg (corresponding to MOEs of 125 and 71, respectively). There is insufficient information concerning the types of sprayers and the volumes of sprays to provide an accurate account of the greenhouse uses.

This scenario is low confidence because both the surrogate data and the DAS study lack sufficient number of replicates to meet the guideline criteria. A biological monitoring study should be designed and conducted to better define this scenario.

(15) Hydraulic Hand-held Sprayer: The only data available to assess this type of high volume spray is the surrogate data available from PHED V1.1. The surrogate data are based on an applicator using a “rights-of-way” type sprayer (i.e., FMC BEAN 300 sprayer and BEAN Royalette Model R-2020T) combined with the unit exposures from mixing/loading liquids. The application portion of the estimate contributed to the majority of the combined unit exposure. The total MOEs for the bark treatment range from 6 to 14. The driving factor in the bark treatment assessment is the volume of spray estimated to be applied. The animal premise treatment is based on a smaller area/volume applied and the total MOE is not of concern.

This scenario is low confidence because the surrogate data lack sufficient number of replicates to meet the guideline criteria. A biological monitoring study should be designed and conducted to better define this scenario. In the meantime, the MOEs are of concern for the handling large amounts of chlorpyrifos for bark treatment in nurseries and citrus groves.

(16) Dry Bulk Fertilizer: No data are available to estimate the amount of chlorpyrifos handled or to estimate the potential exposure. More information on the use pattern needs to be submitted to the Agency. In addition, a biological monitoring study should be designed and conducted to better define this scenario.

Table 4 **Exposure Variables and MOEs for Agricultural Uses of Chlorpyrifos**									
Exposure Scenario (Scenario#)	**Are Biological Monitoring Data Available? (a)**	**Application Rates (lb ai/acre) (b)**	**Daily Acres Treated (c)**	**Short-Term PPE MOEs**			**Short-Term Eng. Cntrl. MOEs**		
				Dermal	**Inhalation**	**Total**	**Dermal**	**Inhalation**	**Total**
Mixer/Loader Exposure									
Mixing/Loading Liquids for Aerial/Chemigation Application (1a)	Yes MRID No. 44739302	1.5 cranberries, corn	350	39	56	23	78	160	52
		3.5 citrus (d)	100	59	83	34	120	240	78
Mixing/Loading Liquids for Groundboom Application (1b)	Yes MRID No. 42974501	1.5 predominant max	80	170	240	100	Target MOE reached at PPE		
		5.0 tobacco max	80	51	73	30	100	210	69
		2 Sodfarm (includes tobacco/potatoes)	80	130	180	75	250	530	170
		4 Sodfarm	80	64	91	38	130	260	86
		8.0 sodfarm fire ants	10	260	360	150	Target MOE reached at PPE		
Mixing/Loading Liquids for Airblast Application (1c)	Yes MRID No. 43138102	2.0 predominant max such as Fruits & Nuts	40	260	360	150	Target MOE reached at PPE		
		6.0 citrus	20	170	240	100	Target MOE reached at PPE		
Mixing WP for Aerial/Chemigation Application (2a)	No	2.0 predominant max (orchards)	350	DAS is not supporting the open bag formulation for the WP			51	42	23
		3.5 citrus (d)	100				100	83	46
Mixing WP for Groundboom Application (2b)	Yes MRID No. 42974501	1.0 predominant max (brassica)	80				450	360	200
		4.0 soil treatment ornamentals outdoors	10				890	730	400
		1.3 & 3.0 Sodfarm	80				340 / 150	280 / 120	150 / 67
		8.0 sodfarm fire ants (harvest only)	10				4500	3600	200
Mixing WP for Airblast Application (2c)	No	2.0 predominant max	40				450	360	200
		6.0 citrus	20				300	240	130

Table 4 Exposure Variables and MOEs for Agricultural Uses of Chlorpyrifos									
Exposure Scenario (Scenario#)	**Are Biological Monitoring Data Available? (a)**	**Application Rates (lb ai/acre) (b)**	**Daily Acres Treated (c)**	**Short-Term PPE MOEs**			**Short-Term Eng. Cntrl. MOEs**		
				Dermal	**Inhalation**	**Total**	**Dermal**	**Inhalation**	**Total**
Loading Granulars for Aerial Application (3a)	No	1.95 maximum aerial rate	350	150	30	25	3000	300	270
Loading Granulars for Ground Application (3b)	Yes MRID No. 44483501 (3b and 8)	1.0 typical corn	80	1300	260	210	Target MOE reached at PPE		
		2.0 max corn	80	640	130	110	Target MOE reached at PPE		
		3.0 maximum ground rate (tobacco)	80	430	86	71	8600	860	780
Applicator Exposure									
Aerial (Spray) -- Enclosed Cockpit (4a)	No	2.0 orchards	350	No Open cockpit data available			100	150	60
		3.5 citrus (d)	100				200	290	120
Aerial (Granulars) -- Enclosed Cockpit (4b)	No	1.95	350	No Open cockpit data available			320	8	8
Groundboom Tractor (5)	Yes MRID No. 42974501	1.5 predominant max	80	The biological monitoring results (Table A4) indicate that open cabs provide insufficient protection . Therefore, only the enclosed cab MOEs are presented.			580	1400	410
		5.0 tobacco max	80				180	410	120
		4 Sodfarms	80				220	510	150
		8.0 sodfarm fire ants	10				880	2000	610
Airblast Applicator (6)	Yes MRID No. 43138102	2.0 predominant max	40	The biological monitoring results indicate that open cabs are insufficient.			230	190	110
		6.0 citrus	20				150	130	70
Tractor-Drawn Granular Spreader (7) **(PPE is long pants, long sleeved shirt, and no gloves "baseline)**	Yes MRID No. 44483501 (3b and 8)	1.0 typical corn	80	1000	360	270	Target MOE reached at PPE		
		2.0 max corn	80	520	180	140	Target MOE reached at PPE		
		3.0 maximum ground rate (tobacco)	80	350	120	90	690	130	110
Seed Treatment (8)	No	No Data	No Data	No Data			No Data		
Dip Application (Preplant Peaches) (9)	No	No Data	No Data	No Data			No Data		

Table 4
Exposure Variables and MOEs for Agricultural Uses of Chlorpyrifos

Exposure Scenario (Scenario#)	Are Biological Monitoring Data Available? (a)	Application Rates (lb ai/acre) (b)	Daily Acres Treated (c)	Short-Term PPE MOEs			Short-Term Eng. Cntrl. MOEs		
				Dermal	Inhalation	Total	Dermal	Inhalation	Total
Flagger Exposure									
Spray Applications (10) **(PPE is long pants, long sleeved shirt, and no gloves "baseline)**	No	2.0 predominant max	350	50	140	37	2300	1400	880
		3.5 citrus (d)	100	100	290	74	4500	2900	1800
Granular Applications (11)	No	1.95	350	320	340	170	Target MOE reached at PPE		
Mixer/Loader/Applicator Exposure									
Backpack Sprayer (12)	Yes MRID No. 43027901	0.0417 lb ai/gal predominant max / 0.08 lb ai/gal bark beetle treatment / 0.03 lb ai/gal stump treatment	40 gal/day	130 / **68** / 180	700 / 360 / 970	110 / **58** / 150	Target MOE reached at PPE, except for the higher concentration for the beetle bark treatment		
		3.5 citrus bark	1 A/day	63	330	53	Not feasible		
		0.039 lb ai/gal / 750 ft2	1000 ft2	4200	22000	3500	Target MOE reached at PPE		
Low Pressure Handwand (13)	Yes MRID No. 43027901	0.0417 lb ai/gal predominant max / 0.08 lb ai/gal bark beetle treatment / 0.03 lb ai/gal stump treatment	40 gal/day	570 / 300 / 790	700 / 360 / 970	310 / 160 / 440	Target MOE reached at PPE		
		3.5 citrus bark	1 A/day	270	330	150	Target MOE reached at PPE		
		0.039 lb ai/gal / 750 ft2 animal prem.	1000 ft2	18000	22000	10,000	Target MOE reached at PPE		
High Pressure Handwand (greenhouse uses) (14)	Yes MRID No. 43027901	Min. 0.0033 lb ai/gal	1000 gal/day	66	88	38	Not feasible		
		Max. 0.0066 lb ai/gal		33	44	19	Not feasible		

Table 4 Exposure Variables and MOEs for Agricultural Uses of Chlorpyrifos									
Exposure Scenario (Scenario#)	**Are Biological Monitoring Data Available? (a)**	**Application Rates (lb ai/acre) (b)**	**Daily Acres Treated (c)**	**Short-Term PPE MOEs**			**Short-Term Eng. Cntrl. MOEs**		
				Derma l	**Inhalat ion**	**Total**	**Derm al**	**Inha latio n**	**Total**
Hydraulic Hand-held Sprayer for Bark / Pine Seedling Treatment (15)	No	3.5 citrus bark	10 A/day	16	100	14	Not feasible		
		0.08 lb ai/gal bark beetle treatment / 0.16 lb ai/ gal pine seedling treatment /	1,000 gallons	14 / 7	88 / 44	12 / 6	Not Feasible		
		0.039 lb ai/gal / 750 ft2 animal prem	10000 ft2	2,200	13,000	1,900	Target MOE reached at PPE		
Dry Bulk Fertilizer Impregnation (16)	No	1.0 lb ai / 200 lb fertilizer / acre	No Data	No Data			No Data		

(a) Biological monitoring data are available from several chemical-specific studies. Although biological monitoring scenarios are available for some of the scenarios as indicated in this table, passive dosimetry data are presented for comparison because insufficient replicates and/or additional risk mitigation measures were necessary.

(b) Application rates are the maximum labeled rates found on EPA Reg. Nos. 62719-38, -221, -245, -34; -79, -72, -166, -220, 34704-66 (Clean Crop Chlorpyrifos 4E -- sodfarm fire ant rate), 499-367 (499-367 is the only greenhouse label identified), and 10350-22 for animal premise treatments. **"Predominant max"** in this table refers to the most **frequently identified maximum** application rate found on the labels for the specific formulation and equipment type. Typical rates are also included to characterize the chlorpyrifos uses. Not all application rates are included for all crops, instead, a cross-section of rates are used to represent the uses of chlorpyrifos.

(c) Daily acres treated are based on HED's estimates of acreage (or gallonage) that would be reasonably expected to be treated in a single day for each exposure scenario of concern. The sodfarm fire ant rate is restricted on the label for harvest only, therefore, this rate is limited to the amount of sod that may be harvested in a reasonable time frame. Therefore, using the limited data available, approximately 10 acres treated per day are assumed to be the upper range.

(d) The application rates on the Lorsban 4E (EPA Reg. No. 62719-220) and 50W (EPA Reg. No. 62719-39 discontinued as of 1995 and sold as -221) labels indicate that for citrus at the 6.0 lb ai/A rate it is necessary to use 100 to 2,400 gallons per acre dilute spray. Therefore, this rate is not expected to be feasible for an aerial applicator. The label language should be clarified so that the 6.0 lb ai/A rate is for ground only. Additionally, citrus orchards are believed to be relatively small plots and 100 acres per day is assumed in the assessment for aerial applications.

2.2.3 Insufficient Data

The Agency has insufficient exposure data to provide an assessment of seed treatment applications, dip applications (root stock), and dry bulk fertilizer. In addition to exposure data, the types of seed treatment practices for chlorpyrifos need to be submitted (e.g., are the treatments done on site?).

DAS submitted additional information to HED that uses include dip applications for balled and burlapped or containerized stock for fire ant quarantine regulations and for Japanese beetle control for US/Canada transport of nursery stock. The current mixer/loader surrogate data do not appear to be representative for dip treatments in agricultural or nursery/greenhouse settings. Additionally, chemical-specific and/or representative surrogate exposure data and use information are required for reregistration of dry bulk fertilizer (impregnation and application). According to the Lorsban 4E label, chlorpyrifos is applied at a rate of 1 lb ai per 200 pounds of fertilizer per acre and that the mixture must be applied immediately, not stored. More information is needed to properly estimate the exposure/risk. Information needed includes how many acres per day can be treated?; Can the dry bulk fertilizer be prepared at a commercial facility, if so, what is the process and how much active ingredient would be handled in a day?; and What types of surrogate data are available for this scenario? The applicator exposure associated with dry bulk fertilizer applications to citrus groves requires additional data for reregistration.

Finally, there are potential dermal and inhalation exposures to handlers applying eartags to livestock. No chemical-specific or surrogate data are available to assess handler exposure from this specialized use pattern. The Agency estimates that handler dermal and inhalation exposure would be minimal, since the product is impregnated in relatively small quantities into the device as purchased. High end estimates would assume that one percent of the active ingredient impregnated into each eartag would be available on the surface to cause exposure to the applicator's hands. Even with a vapor pressure of 1.87E-5 mmHg, the inhalation exposure should be minimal since the product is applied outdoors, relatively small amounts of active ingredient are handled per day, and the product is impregnated into the eartag. EPA estimates that the only dermal exposure of possible significance might be to the hands. Dermal exposures other than to the hands should be rare. Consequently, in lieu of exposure data upon which to assess risk, EPA will require handlers to wear chemical-resistant gloves in addition to baseline attire while handling/applying the impregnated eartags.

3.0 POSTAPPLICATION EXPOSURES

EPA has determined that there is potential exposure to persons entering treated sites (e.g., scouts and harvesters) after application is complete. Postapplication exposure data were required during the chlorpyrifos DCI of the reregistration process, since, at that time, one or more toxicological criteria had been triggered for chlorpyrifos. Although several studies have been submitted, it was still necessary to use HED's standard values for transfer coefficients and crop-specific residues as substitutes to represent other crops. Activity-specific transfer coefficients are currently being developed by the Agricultural Reentry Task Force (ARTF). Once ARTF submits the activity-specific transfer coefficients, these values, where warranted, will be used to replace the standard values provided below.

3.1 Postapplication Exposures & Assumptions

This section is organized into (1) a brief discussion of submitted studies; (2) a summary of the available dislodgeable foliar residues (DFRs) for sugar beets, cotton, corn, cauliflower, tomato, citrus, almonds, apples, and pecans; (3) a summary of the transfer coefficients used to relate the environmental concentrations (i.e., DFRs) to dermal exposure; and (4) an acknowledgment of the uncertainties in setting the restricted-entry intervals (REIs).

3.1.1 Submitted Studies

The following are the postapplication data submissions used in the risk assessment:

- **MRID No. - 429745-01.** Shurdut, B.A. et al. 1993. Lorsban 4E and 50W insecticides: assessment of chlorpyrifos exposures to applicators, mixer/loaders and re-entry personnel during and following application to low crops.

  Passive dosimetry (dermal and inhalation) and biological monitoring samples (urine analysis) were collected for 10 replicates each of scout reentry into cauliflower and tomato sites. The dermal reentry exposure data were monitored concurrently with the dislodgeable foliar residue (DFR) data approximately 24 hours after chlorpyrifos treatment. DFR data were collected on 0, 1, 2, 3, 5, 7, 14, 21, and 30 days after treatment (DAT). The post-application portion of this study used the Lorsban 50W formulation. The Lorsban 50W was applied by groundboom to cauliflower in Arizona and tomatoes in Florida at 1 lb ai/acre. To summarize, this study meets the acceptability criteria outlined in Subdivision K of the Pesticide Assessment Guidelines except that only five replicates per activity (per crop) were monitored and that the Lorsban 4E label allows for a maximum rate of 2 lb ai/acre. The quality control/quality assurance aspects of the study were adequate.

- **MRID No. - 430627-01.** Honeycutt, R.C. and DeGeare M.A. 1994. Worker reentry exposure to Chlorpyrifos in citrus treated with Lorsban 4E Insecticide.

  A single application of Lorsban 4E was applied using an airblast sprayer at the maximum application rate (6 lb ai/acre) to citrus groves (lemons and oranges) at three sites in CA. The sites are identified as #2 (oranges), #5 (oranges), and #6 (lemons). Five replicates of orange (site #2) harvesting (workers identified in the study as "pickers") were monitored 43 days after treatment (DAT). Monitoring of the reentry workers was intended to be 35 DAT (label PHI), however, the oranges were not ripe. In addition, 10 replicates of pruners were monitored, 48 hours after treatment. The table below summarizes the site specific information.

Summary of Site Specific Information.

Site Number	Crop	Activity Monitored	DAT Activity Monitored	Location
2	Oranges	Pickers (n=5)	43	Tulare County, CA
5	Oranges	Pruners (n=5)	2	Tulare County, CA
6	Lemons	Pruners (n=5)	2	Kern County, CA

The study also monitored dislodgeable foliar residues (DFR) concurrently with the human exposure samples. Additional DFRs samples were collected at 0, 1, 2, 4, 5, 7, 14, 21, 35, 40, and 43 DAT at the various sites. Dosimetry and biological monitoring were conducted to determine potential exposure as well as total absorbed dose. Critical items pertaining to the acceptability of the study identified include (1) only five replicates for pickers were monitored, not the required 10 replicates, and (2) the storage stability for the Chromosorb tubes and urine were not presented in the data submission but instead the registrant indicated their stability. Uncertainty exists in determining the transfer coefficient for the picker at 43 DAT because only five replicates of human exposure were monitored and the DFR data on 43 DAT were all nondetects. The selection of 43 DAT for determining the transfer coefficient when the DFRs are all nondetected is a perplexing problem because samples to monitor citrus harvesting cannot be collected any earlier than 35 DAT (i.e., 35 day PHI). Because a 35 day PHI exists, HED views the use of the estimated transfer coefficient for determining a citrus harvesting REI the best available data. Moreover, the long PHI will render the "harvesting" REI inconsequential. Finally, chlorpyrifos has been successfully monitored in several other data submissions using Chromosorb tubes and urine. Therefore, the lack of storage stability data in this submission will not affect the use of the monitoring data.

- **MRID No. - 447481-01.** Dissipation of Dislodgeable Foliar Residues of Chlorpyrifos from Treated Orchard Trees.

  This study is currently under review by HED. The preliminary DFR results are reported below in Section 3.1.2 and are used in the postapplication assessment.

- **MRID 447481-02:** Gardner, R.C. and Blakeslee, B.A. 1999. Dissipation of Dislodgeable Foliar Residues of Chlorpyrifos from Treated Cotton, Sugar Beet and Sweet Corn Row Crops.

  Two applications of Lorsban 4E, Lock-On and Lorsban 15G were applied 5 days apart to test fields. Test fields were located in CA, TX, MS, OR, MN and IL for Lorsban 4E, CA, AZ and TX for Lock-On and CA, AZ and TX for Lorsban 15G. Applications of products were made at maximum application rate/crop (lb ai/A), for cotton and sugar beets. Lorsban 4E sweet corn applications were 1 lb ai/A which is below the 1.5 lb ai/A maximum rate. Applications of Lock-On were made at the maximum label rates/crop of 0.5 lb ai/A. Lorsban 15G applications to sweet corn was made at the maximum label rate of 1 lb ai/acre. Liquid applications were made using typical tractor mounted boom sprayers and the granular was applied with a motor- or ground-driven dispensing impeller.

This study was conducted June through August, with the plants characterized as healthy and in vigorous growing condition. From the weather data (MRID 448264-01) it appears that no significant rainfall fell during the early collection period and irrigation was in-furrow. This would not contribute to loss of chlorpyrifos on the leaves tested. The data from leaf punches after the second treatment were used to characterize concentration of chlorpyrifos on treated crops and the rate of dissipation. The LOD and LOQ were reported as 0.001 $\mu g/cm^2$ and 0.003 $\mu g/cm^2$ respectively.

The registrant has supplied the Agency with predicted concentration values for chlorpyrifos from the non-linear Minitab regression used in the study. When examining the registrant's predicted values against the raw data collected, the predicted concentrations from 1 day after treatment (DAT) through 7 DAT were significantly under predicted.

Due to the rapid dissipation of chlorpyrifos in the test fields from 0 DAT to 1 DAT, HED used JUMP software to calculate a regression curve from 1 DAT to 7 DAT. The average of the data collected from 0 DAT will be used to calculate the exposure on the day of treatment. The dissipation of chlorpyrifos from 1 DAT to 7 DAT on each field was fit to a regression using the following formula:

$$C_t = A(e^{-kt})$$

Where:
C_t = Concentration of Residue at time t,
A = Constant (Varies with site and formulation),
e = the base of natural logarithms,
k = slope of the curve,
t = postapplication interval from 1 DAT to 7 DAT (1-7 days).

Results from the HED regression for each site are presented in study review and summarized below in this chapter. The Oregon sugar beet data were inconsistent (average 2 DAT and 4 DAT values were higher than average 1 DAT) and could not be well fit by a single curve. Residue levels collected from the granular applications showed no dissipation pattern and were largely non-detects; therefore no calculations were made for the regression of Lorsban 15G.

In addition to these reentry studies, two additional registrant-generated risk assessments were submitted using the collected data. The risk assessments are summarized below. As noted below, the results of these assessments are not used in the Agency’s risk assessment.

- **MRID No. - 430627-02.** Chlorpyrifos: an exposure assessment of reentry workers following application in citrus crops.

  This study is a risk assessment generated by the registrant based on the data submitted in MRID No. 430627-01. In the original exposure monitoring study cited in the registrant-generated assessment, Lorsban 4E was monitored for workers harvesting and pruning in citrus groves. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposure as well as total absorbed dose. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The results, as reported in the registrant-generated assessment, based on using the "t-dist" function in Microsoft Excel 4.0, shows that the probability of a harvester reaching the NOEL of 0.03 mg/kg/day is about 2 in 100,000 and the worst case for pruners is 2 in 10,000 for the NOEL of 0.1 mg/kg/day. However, the Agency does not regulate at the NOAEL but rather at levels less than the NOAEL based on uncertainty factors (e.g., 10x for intra-species variation). Therefore, the Agency used the data to perform its own risk assessment.

- **MRID No. - 429944-01.** Chlorpyrifos: an exposure and risk assessment of workers associated with mixing/loading, application and reentry following ground boom application to low crops.

  This study is a risk assessment generated by the registrant based on the data submitted in MRID No. 429745-01. In the original exposure monitoring study cited in the registrant-generated assessment, LORSBAN 4E and LORSBAN 50W were monitored during mixing/loading, groundboom application, and scouting. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposure as well as total absorbed dose. Only the biological monitoring data were used in the registrant-generated assessment. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The results, as reported in the registrant-generated assessment, based on a Student t-test statistical analysis, show that there is a finite probability (0.6%) for an individual who repeatedly scouts in LORSBAN treated fields to exceed the "NOEL" for multiple exposures to chlorpyrifos. However, the Agency does not regulate at the NOAEL but rather at levels less than the NOAEL based on uncertainty factors (e.g., 10x for intra-species variation). Therefore, the Agency used the data to perform its own risk assessment.

3.1.2 Summary of Dislodgeable Foliar Residues

The postapplication monitoring studies submitted provide DFR data for cauliflower, tomatoes, cotton, sugar beets, corn, citrus, almonds, apples, and pecans. The DFR data in these studies were collected at three sites for each of these crops. Because of the absence of additional DFR data for the various other crops treated with chlorpyrifos, the cotton, sugar beets, and corn DFR data are used as surrogate residue values for other crops. The DFR data from these crops were used as surrogates to calculate potential exposure resulting from harvesting activities for field crops grouped as **"low"**,

"medium", and **"high"** potential for dermal contact. Uncertainties are introduced into the assessment when crop-specific residues are used to estimate residues from other types of crops, however, it is believed to be more realistic than assuming a default initial residue value based on the application rate and an assumed dissipation rate per day. The cauliflower, tomato, citrus, almond, apple, and pecan DFR data are used solely for assessing reentry exposures to those specific crops. All of the DFR data are presented in the tables below.

The residue decline for chlorpyrifos indicates that it quickly dissipates in the first few days after application and then the decline is more subtle. For instance, in most of the crops monitored, the half life of chlorpyrifos for the first part of the curve (i.e., 0 to 7 DAT) is less than 1 day. The second part of the decline curve exhibits a half life of more than 10 days using data from 7 up to 43 DAT. Based on the initial rapid dissipation of chlorpyrifos as shown in the DFR studies, most of the crops were analyzed using the first part of the decline curve for the short-term endpoint (i.e., up to 1 month) to establish the REI. The second part of the decline curve was used to assess the intermediate-term duration to assure that workers exposed in treated fields for 1 to 6 months are adequately protected.

Sugar Beets, Cotton, Corn DFR Data:

The data sets for sugar beets, cotton, and corn (MRID 447481-02) are used to represent field crops with a "low", "medium", and "high" potential for dermal contact, respectively. The data for the three crops listed were monitored at an application rate of 1 lb ai/acre. The crops in the surrogate assessment have application rates of 1 to 2 lb ai/acre and these DFR data are normalized where appropriate. The raw and predicted DFR data at 1 lb ai/acre are provided in the table below.

Summary of Cotton, Sugar Beets, and Corn Dissipation Data Based On a Non Linear Regression.

Crop	Non Linear Regression, Predicted Values									
	DFR (μg/cm^2) -- (Values in Parentheses Are Field Measured Values)								Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
Cotton (LockOn)	0.608	0.0227 (0.018)	0.00898 (0.037)	0.00398	0.00195 (0.003)	0.00102	0.000566	0.000324 (0.0027)	0.86	0.81 to 0.96
Cotton (4E)	1.25	0.0308 (0.036)	0.0162 (0.013)	0.00875	0.00483 (0.0083)	0.00271	0.00153	0.000872 (0.002)	0.95	0.88 to 0.95
Beets	0.600	0.0334 (0.0327)	0.0211 (0.022)	0.0135	0.00872 (0.0083)	0.00571	0.00382	0.00261 (0.0037)	2.9	0.05 to 0.98
Corn	1.10	0.0196 (0.0193)	0.0107 (0.0113)	0.00594	0.00334 (0.0030)	0.00189	0.00108	0.000623 (0.0010)	1.1	0.83 to 0.94

Cauliflower DFR Data:

The cauliflower data (MRID 429745-01) represent DFR levels obtained at an application rate of 1 lb ai/acre using the Lorsban 50W. The maximum labeled rate for cauliflower is 1 lb ai/A on the Lorsban 50W (EPA Reg. No. 62719-221) and 2.0 lb ai/A for the Lorsban 4E (EPA Reg. No. 62719-220 dated 2/1/99). The predicted DFR levels (μg/cm^2), based on the slope and intercept, are normalized (i.e., DFR data multiplied by 2) to account for a potential increase in residues when chlorpyrifos is applied at its maximum application rate of 2 lb ai/acre (Lorsban 4E - EPA Reg. No. 62719-220). Although HED believes that wettable powder formulations may present higher DFRs than liquid formulations, this extrapolation from data collected for wettable powders to potential residues for liquids is necessary because it is the only data available to estimate REIs on the maximum rate. The coefficient of determination (R^2) and dissipation rates for the three cauliflower sites (i.e., sites identified in the study as ABC, DEF, and GHI) are similar. Therefore, all of the data for the three sites were combined for the linear regression. The data did not indicate a biphasic decline and all sampling intervals were used in the decline curve up to and including the nondetects on 21 DAT.

Cauliflower Dissipation Data for Sites ABC, DEF, and GHI Combined and Normalized to the Maximum Application Rate.

Site	DFR (μg/cm^2) -- Predicted Values Based On Log Transformed Data (Values in Parentheses Are Normalized Field Measured Values)							Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
All Sites	1.278 (1.438)	0.995 (1.174)	0.774 (0.732)	0.603 (0.650)	0.469	0.365 (0.376)	0.284	0.221 (0.216)	2.8	0.94

Sites ABC, DEF, and GHI (Yuma, AZ): 0, 1, 2, 3, 5, 7, 14, 21, and 35 DAT, the last two intervals all samples were nondetect and only up to and including 21 DAT are used in the regression; actual monitored data multiplied by 2 to estimate the maximum label application rate.

Tomato DFR Data:

The tomato data (MRID 429745-01) represent DFR levels obtained at an application rate of 1 lb ai/acre using the Lorsban 50W. The R^2 and half-life data for the residues monitored at the three tomato sites (i.e., sites identified in the study as JKL, MNO, and PQR) were compared. Residues monitored at site JKL exhibit the best R^2 value. The raw data from sites MNO and PQR are erratic and were not of use for the assessment. Both the predicted residue values (based on the log transformed data) and the raw data (also normalized by application rate) are provided in the table below. Data for sugar beets, cotton, and corn were submitted during the development of this chapter and were used instead of the tomato data in the crop grouping matrix.

Tomato Dissipation Data for Site JKL Normalized to the Maximum Application Rate.

Site	DFR (μg/cm^2) -- Predicted Values Based On Log Transformed Data (Values in Parentheses Are Normalized Field Measured Values)							Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
JKL	0.480 (4.44)	0.391 (0.698)	0.319 (0.428)	0.260 (0.150)	0.212	0.172 (0.036)	0.140	0.114 (0.064)	3.4	0.75

Site JKL (Florida): 0, 1, 2, 3, 5, 7, 14, 21, and 30 DAT; actual monitored data multiplied by 2 to estimate the maximum label application rate.

Citrus DFR Data:

The citrus data (MRID 430627-01) represent DFR levels obtained at the maximum application rate for citrus of 6 lb ai/acre. Therefore, it was not necessary to normalize the predicted DFR levels (μg/cm^2). The summary of the dissipation data are listed in the table below. The data indicate that the chlorpyrifos dissipation in citrus is biphasic, and therefore, the 0 to 7 DAT sampling intervals were used in determining the predicted residues.

Summary of Citrus and Lemon Dissipation Data Based On Only 0 to 7 DAT Sampling Intervals.

Site	Biphasic: 0 to 7 DAT Sampling Intervals, Predicted Values -- Based On Log Transformed Data									
	DFR ($\mu g/cm^2$) -- (Values in Parentheses Are Field Measured Values)								Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
2	0.99 (1.5)	0.63 (0.21)	0.40	0.25	0.16 (0.096)	0.10 (0.079)	0.064	0.041 (0.074)	1.5	0.83
5	1.25 (1.8)	0.55 (0.55)	0.24 (0.16)	0.10	0.046	0.020	0.0087	0.0038 (0.0076)	0.84	0.92
6	0.76 (1.5)	0.40 (0.37)	0.21 (0.082)	0.11	0.060	0.032	0.017	0.0090 (0.013)	1.1	0.84
All Sites	0.95 (1.6)	0.52 (0.48)	0.29 (0.12)	0.16	0.086 (0.096)	0.047 (0.079)	0.026	0.014 (0.032)	1.2	0.78

a Site 2 (Oranges Tulare County, CA): 0, 1, 4, 5, 7, 14, 21, 35, and 43 DAT, at 1 DAT 4 of the 6 samples were nondetect and are excluded;
Site 5 (Oranges Tulare County, CA): 0, 1, 2, 7, 14, and 40 DAT;
Site 6 (Lemons Kern County, CA): 0, 1, 2, 7, 14, and 35 DAT; and
All Sites: 0, 1, 2, 4, 5, 7, 14, 21, 35, 40, and 43 DAT.

Almond, Apple, and Pecan DFR Data:

The almond, apple, and pecan DFR study is currently under review. The DFR data were analyzed and the results are presented in the table below.

Summary of Almond, Apple, and Pecan Dissipation Data Based On Only 0 to 7 DAT Sampling Intervals.

Crop	Biphasic: 0 to 7 DAT Sampling Intervals, Predicted Values -- Based On Log Transformed Data									
	DFR ($\mu g/cm^2$) -- (Values in Parentheses Are Field Measured Values)								Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
Almond	0.834 (1.76)	0.458 (0.48)	0.251 (0.27)	0.138	0.0756 (0.062)	0.0415	0.0228	0.0125 (0.026)	1.2	0.72
Apple	0.677 (1.47)	0.307 (0.44)	0.139 (0.18)	0.0631	0.0286 (0.018)	0.0130	0.0059	0.0027 (0.0046)	0.88	0.79
Pecan	0.0837 (0.27)	0.0488 (0.043)	0.0284 (0.019)	0.0166	0.0096 (0.010)	0.0056	0.0033	0.0019 (0.0043)	1.3	0.67

Almonds: Sampling intervals of 0, 1, 2, 4, 7, 14, 21, 28, and 35 DAT.
Apples: Sampling intervals of 0, 1, 2, 4, 7, 14 (all ND), 21 (all ND), 28 (all ND), and 35 (all ND) DAT.
Pecans: Sampling intervals of 0, 1, 2, 4, 7, 14 (all ND), 21 (all ND), 28 (all ND), and 35 (all ND) DAT.

3.1.3 Summary of Transfer Coefficients

Transfer coefficients (Tc) are used to relate the leaf residue values to activity patterns (e.g., harvesting) to estimate potential human exposure. Harvesting activities are assessed in this RED using both chemical- and activity-specific transfer coefficients along with surrogate harvesting transfer coefficients from HED's Exposure Science Advisory Council Policy #3 to estimate potential exposure levels for all crops to determine the restricted-entry intervals (REIs). Chemical- and activity-specific transfer coefficients developed to support chlorpyrifos include: (1) citrus harvesting, (2) citrus tree pruning, (3) cauliflower scouting, and (4) tomato scouting. The dermal exposure levels during the activity of **harvesting citrus** were monitored concurrently with the DFR levels in MRID 430627-01. The transfer coefficient for harvesting citrus ranged from 6,650 to 7,494 cm^2/hr and averaged 6,891 cm^2/hr. The transfer coefficient for **pruning citrus trees** during rainy conditions ranged from 2,337 to 3,929 cm^2/hr and averaged 3,213 cm^2/hr; and 1,121 to 1,673 cm^2/hr (average 1,371 cm^2/hr) in dry conditions. The dermal exposure levels during the activity of **scouting in the cauliflower and tomato** fields were monitored concurrently with the DFR levels in MRID 429745-01. The transfer coefficients for scouting are 738 cm^2/hr for cauliflower and 677 cm^2/hr for tomatoes.

Because chemical- and activity-specific transfer coefficients are not available for all crops, it is necessary to group the exposure potential resulting from postapplication activities. These three groupings include **"low"**, **"medium"**, and **"high"** potential for dermal contact. HED's agricultural standard values for transfer coefficients for field crops with a "low", "medium", and "high" potential for dermal contact are 2,500, 4,000, and 10,000 cm^2/hr, respectively. These transfer coefficients are believed to represent a conservative reliable estimate of potential exposures while harvesting or involved in other high contact activities. These transfer coefficient defaults are in use until the Agriculture Reentry Task Force (ARTF) provides activity-specific data. Table 5 presents a matrix for potential activity-specific contact rates and crop groupings used in the postapplication assessment.

Table 5. Postapplication Potential Dermal Contact Rate and Crop Grouping Matrix[a]

Potential for Dermal Contact	Transfer Coefficient (cm^2/hr)[b]	Activities	Application Rate (lb ai/A) (Reg. No. 62719-220)	Example Crops
Low	2,500	Harvest	1	Alfalfa, asparagus, small grains (wheat, sorghum, milo), soybeans
			2	Cole crops, mint
		Sort/Pack	1	Sugar beets
			2	Radishes (up to 2.75 lb ai/A), rutabagas (up to 2.25 lb ai/A)
Medium	4,000	Harvest, stake/tie, scout, irrigate	1	Cranberries, strawberries
		Irrigate	1	Christmas trees
		Late season scouting	1	Cotton
High	10,000	Hand Harvest (also includes detasseling of corn)	1	Sunflowers (up to 1.5 lb ai/A), corn (up to 1.5 lb ai/A as a foliar treatment)
			2	Sweet potatoes
		Cut/harvest, prune, transplant, ball/burlap	1	Christmas trees

[a] Citrus foliar treatments are assessed separately using the chemical-specific data in MRID 430627-01; Tree Nuts & Fruits are assessed separately using the citrus data (normalized to 2 lb ai/A) as a surrogate.
[b] Standard values for transfer coefficients are from HED Exposure Science Advisory Council (SAC) Policy #3 dated May 7, 1998.

Finally, grape harvesting activities were not analyzed separately because the only chlorpyrifos use for grapes is a vine based treatment (i.e., pouring solution at the base of the grape vine), no foliar treatments were identified. In addition to the foliar chlorpyrifos treatments, there are many soil incorporated/directed treatments. These soil incorporated/directed treatments, depending upon the postapplication activities, often result in less postapplication exposure than the foliar treatments. Examples of soil incorporated/directed uses include treatments for onions, peanuts @ 2 lb ai/acre, sweet potatoes @ 2 lb ai/acre, corn @ 3 lb ai/acre, and tobacco @ 3 lb ai/acre (5 lb ai/acre in NC, SC, and VA). Even though these treatments are soil incorporated/directed, potential exposure exists for transplanting tobacco (label allows transplanting within 24 hours after treatment) and onion sets or other activities that involve disturbing the soil such as hoeing. At this time, there are insufficient exposure and soil residue data to assess the potential risk from soil incorporated/directed uses of chlorpyrifos.

3.1.4 Summary of Uncertainties

The postapplication exposure assessment encompasses the major uses of chlorpyrifos throughout the country. It is difficult to assess all of the "typical" agricultural uses for chlorpyrifos (i.e., actual or predominant application rates -- "predominant" being defined as the most frequently found rates on labels). DAS recently submitted a use survey (i.e., Mar Quest research study) to assist the Agency in determining how chlorpyrifos is used in the field. However, at the time that this chapter was developed, the Mar Quest study had just been received and its scope has not been reviewed. Once reviewed, the Agency will incorporate the appropriate information from this survey to better characterize chlorpyrifos risk estimates. In the mean time, an assessment has been developed which is believed to be realistic based on *allowable uses on the labels* and yet provides a reasonable certainty that the exposures are not underestimated. Some of the specific DAS requests for clarification and interpretation of product labels and application techniques are included. The assumptions and uncertainties are identified below to be used in risk management decisions:

- ***Crop Specific Residues:*** A multitude of crops are treated with chlorpyrifos and crop-specific residue data are not available for all situations. Therefore, the use of the available data to "simulate" residues on other crops introduces uncertainties in the setting of restricted-entry intervals. It is reasonable to believe that the residues monitored in the available studies approximate the residues on other crops, but the extent that these residues might be an under- or overestimate is unknown.

- ***Extrapolation/Normalization of Residues:*** The cauliflower residues in MRID 429745-01 were not monitored at the maximum application rate specified on chlorpyrifos labels (Lorsban 4E - EPA Reg. No. 62719-220). Therefore, the residues were normalized from the rate used in the study (1 lb ai/acre) to reflect the maximum application rate of 2 lb ai/acre. Normalizing the residues to the maximum application rate is a standard practice used by HED so as not to underestimate the residues. A new DFR study is recommended for cauliflower using the liquid formulation at the 2 lb ai/acre rate to determine if the WP formulation results in higher DFRs than the liquid formulation.

- ***Transfer Coefficients:*** The transfer coefficients selected are based on the activities monitored in the submitted studies and on HED's policy for surrogate values. HED is using these estimated transfer coefficients until the results of the Agricultural Reentry Task Force (ARTF) are available. These values are believed to be reasonable highend estimates that would not underestimate the risks. The preliminary results of the ARTF indicate that for harvesting nuts the “tree shaker” transfer coefficient (i.e., only exposure resulting from foliar contact) is significantly lower than that of citrus harvesting. Data are not being collected for exposure to soil/dust from the windrowing process.

- ***Exposure Frequency/Duration:*** The amount of time (e.g., days) that a worker would be involved in postapplication activities in chlorpyrifos treated fields is not available. However, based on the exposure duration for short-term being defined as up to 1 month, and the intermediate-term duration from 1 to 6 months, this postapplication assessment is believed to be more reflective of the postapplication exposure than the traditional HED short-term definition of 1 to 7 days. The short-term REIs are calculated at the residue level predicted on a specific day after treatment; subsequent declining residue levels (i.e., average residues under the dissipation curve) are not incorporated into the short-term assessment. The daily dissipation of residues to reflect a declining worker’s exposure over the 30 day period for the short-term assessment was not factored into the assessment because of (1) the lack of information pertaining to exposure frequency/duration of workers in treated fields, (2) harvesters may travel to multiple treated fields thus encountering higher residues in each field, and (3) the time-to-effect in the 21-day dermal study was only 4 days. Therefore, the short-term assessment is protective of workers rotating into freshly treated fields at the entry interval up to 30 days. Conversely, the intermediate-term assessment factors daily declining residues into the calculation of an average residue value over a time frame of 30 days. The intermediate-term assessment is protective for workers working in treated fields for 30 days and then rotating into freshly treated fields, repeating the process for up to a 6 month timeframe. Note: For some of the crop residues only an average of 7 days was used if the results of the intermediate-term MOEs reached the target of 100 at the short-term REI. Although the shorter timeframe may overstate the intermediate-term risks, expending the resources to determine the second part of the decline curve was not necessary if refinements to the REI were not warranted.

- ***Timing of Application:*** Many of the chlorpyrifos treatments (e.g., citrus and tree fruits) are tree trunk/bark applications in the dormant to early season. Nonetheless, REIs are established for harvesting to be inclusive of all other activities (e.g., harvesting during the less frequent foliar treatments, irrigation, stake/tie, prop). Scouting and pruning activities are assessed separately. Moreover, application restrictions such as the number of applications per year (e.g., 1 application per year for citrus at the maximum rate, 1 at the maximum rate for apples, and 1 to 3 for almonds), preharvest intervals (e.g., 30 days for ECs on broccoli), and retreatment intervals (e.g., none for almonds to 30 days for citrus) provide additional insight into the protective nature of the intermediate-term assessment for postapplication exposures. For a complete listing of application timings and use limitations see the revised Product and Residue Chemistry Chapter (Barcode D259613 dated 10/1/99).

- ***Children Postapplication Activities (e.g., harvesting and/or bystander)*:** GAO (2000) raised the following question in its report, *Pesticides: Improvements Needed to Ensure the Safety of Farmworkers and Their Children* -- How can the current restricted entry intervals (REIs) calculations which are based on body weights be protective of children? This report surmised that "other factors being equal" the lower body weight of a child would extend the REI. However, the dermal dose used to establish REIs is based on several factors in addition to the median adult male/female body weight including the median adult male/female surface area and the transfer coefficient (related to body surface area). The following calculation describes HED's position that the current method to estimate REIs is protective of children 12 years old that are harvesting crops. The 12 year old age was selected from the child labor requirements in agriculture under the Fair Labor Standards Act (FLSA). Exceptions to the FLSA include 10 year olds that are permanent residents that "hand harvest short season crops" and any minors of the farm owner/operator. The quantitative data indicate that the median body surface area (cm^2) to the median body weight (kg) ratio of a 12 year old compared to that of an adult results in a 18 percent underestimate of the child [(((child 13700 cm^2/44 kg) - (adult 18440 cm^2/70 kg)) / (adult 18440 cm^2/70 kg)) x 100]. Historical transfer coefficients indicate that the higher the productivity of a worker the higher the transfer coefficient. HED believes that it is reasonable to assume that the productivity of a 12 year old is less than that of an adult. Transfer coefficients for 12 year olds are not available at this time. The surrogate transfer coefficients used by HED for the majority of chlorpyrifos activities are believed to represent the upper range of values. HED believes that transfer coefficients for 12 year olds are lower than for adults and that the difference in the magnitude of the transfer coefficient will nullify the 18 percent underestimate attributed to the ratio of body surface area to body weight.

Assessment of non-occupational exposures of children under 12 years old who accompany their parents into chlorpyrifos-treated fields is difficult to estimate. We know that the body surface area to body weight ratio of a child less than 12 years old is different from an adult. For example, the body surface area to body weight ratio of a 6 year old compared to that of an adult is ~ 40 percent. All other exposure factors being equal, the exposure of a 6 year old would be underestimated by ~ 40 percent. However, "all other exposure factors" are not equal. Methodologies to estimate dermal and/or incidental oral exposure from crop residues for younger children accompanying adults into treated fields are not available at this time. The results of HED's child assessment (see Residential Chapter D263891) of the DAS biological monitoring study (MRID 430135-01) measuring absorbed doses to adults "playing" on treated lawns indicated that "playing" activities on treated lawns exceed HED's level of concern. HED has the same type of concerns that children under 12 years old that venture into treated fields may not be sufficiently protected at the estimated REIs.

3.2 Risk From Postapplication Exposures

This section is organized into two subsections. The first subsection discusses the REIs for each of the crop groupings. The second subsection discusses the scenarios for which insufficient data are available to determine the REI or the import of the spray drift/track-in exposures to children in agricultural areas.

3.2.1 Summary of REIs

Crop Grouping Matrix

The calculated daily dermal absorbed dose and MOEs based on the DFR data and transfer coefficients discussed in Table 5 in the *Postapplication Exposures & Assumptions* section above, are presented in Appendix B, Tables B1 through B4. These tables present the short- and intermediate-term surrogate assessments that are designed to encompass the majority of harvesting scenarios for chlorpyrifos treated crops at the application rates of 1 and 2 lb ai/acre. For the short-term assessments, the dermal absorption of chlorpyrifos is not used in the estimate of absorbed dermal dose because the toxicological endpoint is from a 21-day dermal study. The intermediate-term assessment uses a 3 percent dermal absorption because the toxicological endpoint is from an oral study.

The DFR data used in the surrogate assessments for field crops with a “low”, “medium”, and “high” potential for dermal contact activities are from MRID 447481-02 (specifically from sugar beets, cotton, and corn). These DFR data were generated at an application rate of 1 lb ai/acre. The maximum label rates representing the crops that fall into these three categories are 1 and 2 lb ai/acre on the Lorsban 4E and 50W labels. Therefore, it was necessary to provide REIs at the 1 lb ai/acre rate and the normalized rate of 2 lb ai/acre to reflect the residues at the higher chlorpyrifos application rate. Because the DAS studies were not designed to monitor the DFR at the maximum allowable application rates, HED assumed a linear relationship between DFR and the application rate in normalizing the residues (i.e., multiplied the DFR by a factor of 2). A summary of the field crops with a “low”, “medium”, and “high” potential for dermal contact activities and the associated crops are presented in Table 5 of the *Postapplication Exposures & Assumptions* section. Note: Any crops not specifically mentioned and are within the scope of the surrogate assessment will need to be placed into the matrix at a later date.

Table 6 presents the summary of the restricted-entry intervals (REIs) for the “low”, “medium”, and “high” potential dermal contact rates as presented in detail in Appendix B, Tables B1 through B4. The REI is initially calculated using the short-term toxicity data and the exposure level that is estimated for the day after treatment (DAT) that the MOE is 100 or greater. Once the short-term REI is set, the intermediate-term exposure is calculated using the average residues from the second part of the residue decline curve. The second part of the decline curve is calculated by defining the starting point of the curve as the DAT that the short-term REI was set and then using the sampling intervals in the study. Once the second part of the curve is established, the average residue value over 30 days (or less) is used to estimate the exposure. Less than 30 day intervals were used in situations where refinements in the average residues were not warranted because the short-term REI was sufficiently protective. The intermediate-term of 1 to 6 month duration of exposure activities (i.e., days engaged in sort/pack, irrigation, harvesting, etc.) is used to be protective of those individuals that may be exposed greater than 1 month. Table 6 presents both the short-term (1 to 30 days) and intermediate-term (1 to 6 months) assessment of REIs. The intermediate-term evaluation indicates that the short-term REIs of 1 day are also protective for workers exposed from 1 to 6 months except for the High crop grouping at the 2 lb ai/acre rate. A REI of 2 days is required for those crops in the High potential for dermal contact grouping at the 2 lb ai/acre rate.

Table 6. Summary of the Short- and Intermediate-Term REIs for the Contact Rates and Crop Grouping Matrix.

Potential for Dermal Contact	Short-Term REIs (≤30 days)		Intermediate-Term REIs (1 to 6 months)	
	1 lb ai/A	2 lb ai/A	1 lb ai/A	2 lb ai/A
LOW	1	1	1st part of decline curve; Avg DFR from 1 to 7 days, MOE=280	1st part of decline curve; Avg DFR from 1 to 7 days, MOE=140
MEDIUM	1	No crops	1st part of decline curve; Avg DFR from 1 to 7 days, MOE=230	No crops
HIGH	1	1	1st part of decline curve; Avg DFR from 1 to 7 days, MOE=140	2nd part of decline curve; Avg DFR from **2** to 7 days, MOE=110

No crops were identified on the labels at the 2 lb ai/acre rate in the "medium" grouping.

Postapplication exposures are mitigated for crop advisors/scouts using entry restrictions, not restricted-entry intervals. Since under the Worker Protection Standard for Agricultural Pesticides -- 40 CFR Part 170, crop advisors/scouts are defined as handlers, the Agency can permit such persons to enter treated areas to perform scouting tasks, provided they are using required personal protective equipment. Additionally, the crop advisor exemption allows certified or licensed crop advisors to choose appropriate protection to be utilized while performing crop advising tasks in treated area for themselves and for their employees. However, the WPS exemption does not exempt crop advisors from regulation under FIFRA-Sections 3, 6, and 12, and Title 40 CFR Part 156.204(b)-Labeling in regard to risk concerns identified through reregistration or other EPA risk assessment /data evaluations processes.

The biological monitoring results of the cauliflower and tomato study (MRID No. 429745-01) indicate that the **scouts** may require an entry restriction for engaging in scouting activities. The absorbed dose from the biological monitoring (as monitored in the study) for the five replicates of 4-hour scouting activities in cauliflower and tomatoes are 0.0022 and 0.00076 mg/kg/day, respectively. These absorbed doses for the 4-hour monitoring period (monitored 24 hours after treatment) correspond to short-term MOEs of 68 and 200, respectively (MOE = (dermal NOAEL of 5 mg/kg/day x 0.03 dermal absorption) / absorbed dose). The biological monitoring results at 24 hours after treatment are compared to a transfer coefficient approach to setting REIs because (1) the biological monitoring results are represented by only 5 replicates, (2) insufficient information is available that scouting activities are limited to 4-hours, and (3) the entry restriction is to be extrapolated for all crops in the matrix so the highest (i.e., most conservative) residues were selected. The scout transfer coefficients are 738 and 677 cm^2/hr for cauliflower and tomatoes, respectively. To capture potential scouting exposures for all crops listed in the grouping matrix (see Table 5), the higher transfer coefficient of 738 cm^2/hr is used along with the DFR data for sugar beets because it exhibited the longest half live. Note: Although cotton presented a slightly higher initial residue level, the results of the cotton postapplication exposures are similar to that of sugar beets. Table 7 provides the absorbed dose and MOEs for short- and intermediate-term exposure durations. As illustrated in Table 7, the biological monitoring results and the transfer coefficient approach are in agreement that a 24 hour entry restriction is needed for scouts.

Table 7. Short- and Intermediate-Term MOEs for **Scouting** Various Crops Associated with the Grouping Matrix (see Table 5).

Exposure Duration	DAT[a]	Sugar Beet DFR Data and Cauliflower Scouting Transfer Coefficient as Representative Scenario for all Low, Medium, and High Crop Groupings					
		1 lb ai/acre			2 lb ai/acre		
		DFR (μg/cm^2)[b]	Potential Exposure (mg/kg/day)[c]	MOE[d]	DFR (μg/cm^2)[b]	Potential Exp. (mg/kg/day)[c]	MOE[d]
Short-term assessment protective of scouts rotating into freshly treated fields daily for up to 30 days							
Short-Term	0*	0.600	0.051	99	2.4	0.202	25
	1	NA	NA	NA	0.133	0.0113	440
Intermediate-term assessment protective of scouts rotating into freshly treated fields every week for up to 6 months							
Intermediate- Term	DAT Interval	Average Beet DFR (μg/cm^2)	Avg. Absorbed Dose(mg/kg/dy)[c]	MOE[d]	Average DFR (μg/cm^2)	Avg. Absorbed Dose(mg/kg/dy)[c]	MOE[d]
	1 to 7	0.0127	3.2E-5	930	0.0254	6.4E-5	470

* 0 days corresponds to a 12-hour REI -- when sprays have dried

a DAT = Days after treatment. The DAT interval for the intermediate-term assessment was selected based on the short-term REI as the starting point and using 7 days of declining residues.

b DFR (μg/cm^2): sugar beet data from MRID 447481-02 monitored at 1 lb ai/A and normalized (multiplied by 2) to account for the maximum application rate of 2 lb ai/A. The average DFR for DAT 1 through 7 for sugar beets (see Table B2 and B4 for data on cotton and corn) is based on the daily DFRs from the first part of the decline curve because the short-term REI is only 1 day.

c Potential Exposure/Absorbed Dose (mg/kg/day) = (DFR (avg. DFR for intermediate-term calculations) x Tc (738 cm^2/hr) x 0.001 mg/μg conversion x 1.0 absorption factor for short-term and 0.03 for intermediate-term x 8 hrs/day) /70 kg

d MOE = NOAEL / Potential exposure (short-term) and Absorbed Dose (intermediate-term) (mg/kg/day); where short-term NOAEL is 5 mg/kg/day and intermediate-term is 0.03 mg/kg/day.

Cauliflower

Cauliflower REIs are assessed separately from the crop grouping matrix because of the chemical-specific DFR data available that indicate that the residues decline at a different rate then that of the other crops. As presented in Section 3.1.2, the actual cauliflower DFR data match the linear prediction with an R^2 of 0.94. The REIs are for harvesting activities assessed at 1 and 2 lb ai/acre using HED's transfer coefficient policy. The transfer coefficient from that policy is 2,500 cm^2/hour. The short-term assessment is protective of harvesters rotating daily into freshly treated fields at the REI for 30 consecutive days. Because the cauliflower harvesting season is a minimum of 60 days with greater than 96 percent of respondents reporting a 90 day maximum (USDA 1979), an intermediate-term assessment has also been conducted using the 30 day average residue values. The intermediate-term assessment is protective of harvesters being exposed from 1 to 6 months to residue values equal to the 30 day average of approximately 0.06 μg/cm^2. The DFR, dermal dose, and MOE calculations are presented in Appendix B, Table B9 for the short-term assessment and Table B10 for the intermediate-term assessment. The summarized results of the cauliflower REIs are presented in Table 8. The REI should be set at 7 and 10 days for the 1 and 2 lb ai/acre rates, respectively.

Table 8. Cauliflower Short- and Intermediate-Term Harvester REIs.

Short-Term REIs		Intermediate-Term REIs	
1 lb ai/A	2 lb ai/A	1 lb ai/A	2 lb ai/A
5 days	8 days	7 days	10 days

Table 9 presents the required entry restrictions for scouting of 1 day and 3 days for 1 and 2 lb ai/A, respectively. The chemical-specific DFR and activity-specific scouting data for cauliflower were used in the assessment.

Table 9. Cauliflower Short- and Intermediate-Term MOEs for **Scouting**.

Exposure Duration	DAT[a]	Cauliflower DFR and Activity-specific Transfer Coefficient (738 cm^2/hr)					
		1 lb ai/acre			2 lb ai/acre		
		DFR ($\mu g/cm^2$)[b]	Dose (mg/kg/day)[c]	MOE[d]	DFR ($\mu g/cm^2$)[b]	Dose (mg/kg/day)[c]	MOE[d]
Short-Term	0*	0.639	0.054	93	1.28	0.108	46
	1	0.497	0.042	120	0.995	0.084	60
	2	--	--	--	0.774	0.065	77
	3	--	--	--	0.603	0.051	98
Intermediate- Term	1 to 31	0.0724 (average)	0.00018	160	--	--	--
	3 to 33	--	--	--	0.0439 (average)	0.00021	150

* 0 days corresponds to a 12-hour REI -- when sprays have dried
a DAT = Days after treatment.
b DFR ($\mu g/cm^2$): cauliflower data from MRID 429745-01 monitored at 1 lb ai/A and normalized (multiplied by 2) to the maximum application rate.
c Absorbed Dose (mg/kg/day) = (DFR x Tc (738 cm^2/hr) x 0.001 mg/μg conversion x 1.0 absorption factor for short-term and 0.03 for intermediate-term x 8 hrs/day) /70 kg
d MOE = NOAEL / Absorbed Dose (mg/kg/day); where short-term NOAEL is 5 mg/kg/day and intermediate-term is 0.03 mg/kg/day

Citrus

The REIs and scouting entry restrictions for citrus, based on the data in MRID 430627-01, are presented in Appendix B, Tables B5 and B6 for short- and intermediate-term durations, respectively. In addition to the chemical-specific DFR data and measured transfer coefficients for pruners and harvesting, HED's default transfer coefficient of 1,000 cm^2/hr is used to assess scouting activities in citrus. The transfer coefficients were developed by the registrant (verified by HED) using the passive dosimetry portion of the data submission. The average harvesting transfer coefficient is 6,891 cm^2/hr (range 6,650 to 7,494 cm^2/hr); average pruner in rainy conditions is 3,213 cm^2/hr (range 2,337 to 3,929 cm^2/hr); and average pruner in dry conditions is 1,371 cm^2/hr (range 1,121 to 1,673 cm^2/hr). The harvesting REI is presented as a high-end postapplication activity, even though the timing of the citrus application (i.e., early season) and long preharvest interval (PHI) may render the REI for harvesting inconsequential. This high-end activity can be used for all other maintenance activities in citrus groves. Table 10 presents the summary of the citrus restricted-entry intervals (REIs) and scouting entry restrictions as presented in detail in Appendix B. The REI is initially calculated using the short-term toxicity endpoints at the exposure level that is estimated for the day after treatment (DAT) that the MOE is 100 or greater. Once the short-term REI is set, the intermediate-term exposure is calculated using the average residues from the second part of the residue decline curve. The second part of the decline curve is calculated by defining the starting point of the curve as the DAT that the short-term REI was set and then using the sampling intervals in the study. Once the second part of the curve is established, the average residue value over 30 days (or less) is used to estimate the exposure. The intermediate-term of 1 to 6 month duration of exposure activities (i.e., days engaged in sort/pack, irrigation, harvesting, etc.) is used to be protective of those individuals that may be exposed greater than 1 month. Table 10 presents both the short-term (1 to 30 days) and intermediate-term (1 to 6 months) assessment of REIs.

Table 10. Summary of the Short- and Intermediate-Term REIs for Citrus Worker Activities.

Activity	Short-Term REIs (1 to 30 days)	Intermediate-Term REIs (1 to 6 months)	REI Summary
Scouts (entry restrictions)	2	First part of decline curve; Avg DFR data from 2 to 32 DAT, MOE = 230	2 days
Pruning (dry conditions)	2	First part of decline curve; Avg DFR data from 2 to 32 DAT, MOE = 170	2 days
Pruning (wet conditions)	4	Second part of decline curve; Avg DFR data from 5 to 35 DAT, MOE = 220	5 days
Harvesting	5	Second part of decline curve; Avg DFR data from 5 to 35 DAT, MOE = 220	5 days

Tree Nuts & Fruits

Chemical-specific DFR data are available for almonds, apples, and pecans (see *Postapplication Exposure Section*). The DFR data for almonds, apples, and pecans are believed to be an adequate surrogate to represent other tree nuts and fruits such as filberts, walnuts, pears, plums, prunes, and peaches. The tree fruit treatments range from the dormant to early season (EPA Reg. No. 62719-220) to foliar sprays. Although the timing for some of the tree nut applications are such that harvesting REIs are not necessary (i.e., the early season applications), they are provided to represent the high-end postapplication activities until such time that the ARTF data are provided for other activities.

The citrus transfer coefficients (i.e., 6,891 cm^2/hr) in MRID 430627-01 are used as surrogate data to assess the REIs for tree nuts and fruits because no other exposure data were submitted for this purpose. [Note: the standard value used by HED for “tree crops” is 10,000 cm^2/hr.] Therefore, this assessment is only meant to be a range-finder for tree nuts until specific activities are identified and the appropriate transfer coefficients determined. The assessment for tree nuts is considered a range finder because the nuts (e.g., almonds/pecans) are not harvested by hand but rather shaken from the tree. The potential exposure results from workers being under the tree when it is shaken and from potential worker contact with dust/soil during the windrowing process. The ARTF data recently submitted indicate that the transfer coefficient for foliar exposure during “shaking” is significantly less than the citrus harvesting transfer coefficient used as a range finder. However, the ARTF transfer coefficient is based solely on foliar contact and does not include potential dust/soil exposure during the windrowing process. The significance of the soil/dust is based on a longer ½ life in soil than foliage. Nonetheless, a more accurate tree nut assessment is not a high priority at this time because the preharvest interval (PHI) for trees nuts such as almonds is 14 days.

The REI assessment is presented in Appendix B, Tables B7 and B8 for short- and intermediate-term durations, respectively. Table 11 presents the summary of the restricted-entry intervals (REIs) and scouting entry restrictions as presented in detail in Appendix B. The REI is initially calculated using the short-term toxicity data at the exposure level that is estimated for the day after treatment (DAT) that the MOE is 100 or greater. Once the short-term REI is set, the intermediate-term exposure is calculated using the average residues from the second part of the residue decline curve. The second part of the decline curve is calculated by defining the starting point of the curve as the DAT that the short-term REI was set and then using the sampling intervals in the study. Once the second part of the curve is established, the average residue value over 30 days (or less) is used to estimate the exposure. The intermediate-term of 1 to 6 month duration of exposure activities (i.e., days engaged in sort/pack, irrigation, harvesting, etc.) is used to be protective of those individuals that may be exposed greater than 1 month. Table 11 presents both the short-term (1 to 30 days) and intermediate-term (1 to 6 months) assessment of REIs. The results of the intermediate-term assessment indicate that the short-term REIs are not sufficiently protective and that the REIs need to set using the intermediate-term endpoint. The harvesting (and all other high exposure activities) REIs for almonds, apples, and pecans are 7, 4, and 2 days, respectively.

Table 11. Summary of the Short- and Intermediate-Term Restricted-Entry Intervals (REIs) for Tree Nut & Fruit Worker Activities.

Activity	Short-Term REIs (1 to 30 days)			Intermediate-Term REIs (1 to 6 months)		
	Almonds	Apples	Pecans	Almonds	Apples	Pecans
Scouts (entry restriction)	2 days	1 day	0 days	2 days	1 day	0 day
Harvesting	5 days	3 days	1 days	7 days[a]	4 days[b]	2 days[c]

a Second part of decline curve based on sampling intervals from 7, 14, 21, 28 and 35 DAT.
b Second part of decline curve based on sampling intervals from 4, 7, and 14 DAT (all other intervals nondetect).
c Second part of decline curve based on sampling intervals from 2, 4, and 7 DAT (all other intervals nondetect).

3.2.2 Insufficient Data

Insufficient Data for REIs

At this time, there are insufficient data to adequately address the REIs for (1) turf harvesting at sodfarms (the Agency is currently analyzing recently submitted turf DFR data), (2) ornamental and greenhouse uses, and (3) soil incorporated/directed uses.

(1) turf dissipation data have been recently submitted (MRID 448296-01) and HED is currently analyzing the data. The existing data (MRID 430135-01) for turf residues are insufficient to calculate dissipation over time. The preliminary results using the turf study (MRID 448296-01) indicate a 48 hour REI is necessary for sod harvesting when estimated using the standard transfer coefficient value of 10,000 cm^2/hr.

(2) The ornamental uses are of concern, specifically postapplication activities such as pruning,

transplanting, and burlap/balling. The National Agricultural Pesticide Impact Assessment Program (NAPIAP 1996) reports chlorpyrifos is widely used for a broad range of insect applications including wood-boring, foliage feeding, sucking pests, and soil-borne. NAPIAP (1996) also reports that although chlorpyrifos use represents only 5 percent of the total pounds of active ingredients in greenhouse/nursery operations, it is used by 35 percent of the survey respondents. It is obvious that chlorpyrifos is an important chemical for the industry, especially as a tool for resistance management. With such reliance by an industry, it is important to collect additional use information, greenhouse DFR data, and biological monitoring data to develop transfer coefficients for various greenhouse/nursery activities. There are insufficient information concerning the timing of the applications in relation to the postapplication activities and a lack of residue data (foliar and bark treatments) to assess the REIs for the ornamental/greenhouse uses.

(3) The soil incorporated/directed uses that may involve postapplication exposures (e.g., planting tobacco within 24 hours of treatment) are also of concern.

Based on these concerns and lack of data, HED recommends that data be submitted to support these uses for reregistration. Finally, the Agency estimates that postapplication exposures following applications of eartags to livestock would be minimal. Worker contact with the eartags after they are applied would be incidental and rare. Therefore, no postapplication exposure and risk assessment are warranted and no entry restrictions apply.

Insufficient Data to Assess Residential Spray Drift

HED has concerns for the potential for children's exposure in the home as a result of agricultural uses of chlorpyrifos. Environmental concentrations of chlorpyrifos in homes may result from spray drift, track-in, or from redistribution of residues brought home on the Farmworkers clothing. Potential routes of exposure for children may include incidental ingestion and dermal contact with residues on carpets/hard surfaces. There are limited data in literature that quantifies the levels of chlorpyrifos in household dust and soil samples. These residues may persist and the resulting exposures are of a potential chronic nature. Given the sensitivity of the long term endpoint coupled with the 100x uncertainty factor and 10x FQPA factor (Rfd = 0.00003 mg/kg/day), even low levels of chlorpyrifos are of concern if those levels are available for children's exposure. It is not known at this time if the low levels in carpet dust and/or soil would correspond to an absorbed dose in a child. The results from two journal articles are briefly summarized below to demonstrate that elevated chlorpyrifos residues are found in "agricultural" homes and are found at a higher frequency than that of "non agricultural" homes.

Simcox et al. (1995) collected house dust and soil samples in children's play areas in and around homes adjacent to apple and pear orchards. In this literature study, chlorpyrifos levels in house dust were found in 98 percent (total 48 families) of the homes of farmers and farm workers. The mean value was 429 ng/g and samples ranged from nondetect to 3,585 ng/g. The house dust levels for the "reference" families (n=11, defined as not working in agriculture and more than 1/4 mile from orchards) averaged 168 ng/g and ranged from nondetect to 483 ng/g. The soil concentrations averaged 17 ng/g for the agricultural families (range nondetect to 234 ng/g) while the “reference” families averaged 11 ng/g (range nondetect to 39 ng/g). The house dust levels were monitored using a HVS-3 vacuum. This type of sampler may potentially overestimate the residues that are available in carpets for human exposure.

Bradman et al. (1997) also monitored house dust in homes along with handwipe samples from children. The highest chlorpyrifos levels in house dust were found in farm worker residents. The results of the house dust are not reported here because the homes and surfaces monitored varied and contain small sample sizes. The values reported for chlorpyrifos residues on the farm worker’s children’s hand (n=4, ages 1 to 3) are ND, ND, 20, and 100 ng. Readers are referred to the article for a more in-depth review.

The chlorpyrifos assessment reflects the Agency’s current approaches for completing residential exposure assessments based on the guidance provided in the *Draft: Series 875-Occupational and Residential Exposure Test Guidelines, Group B-Postapplication Exposure Monitoring Test Guidelines*, the *Draft: Standard Operating Procedures (SOPs) for Residential Exposure Assessment*, and the *Overview of Issues Related to the Standard Operating Procedures for Residential Exposure Assessment* presented at the September 1999 meeting of the FIFRA Scientific Advisory Panel (SAP). The Agency is, however, currently in the process of revising its guidance for completing these types of assessments. Modifications to this assessment shall be incorporated as updated guidance becomes available. This will include expanding the scope of the residential exposure assessments by developing guidance for characterizing exposures from other sources already not addressed such as from spray drift; residential residue track-in; and exposures to farm worker children.

4.0 ADDITIONAL OCCUPATIONAL EXPOSURE STUDIES

Handler Studies

Risk mitigation measures need to be discussed with the registrant prior to requesting any additional handler exposure studies.

Post-Application Studies

Risk mitigation measures need to be discussed with the registrant along with reviewing the Agricultural Reentry Task Force data prior to requesting any additional postapplication exposure studies.

5.0 REFERENCES

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APPENDIX A

SHORT-TERM HANDLER EXPOSURE/RISK

TABLES A1 THROUGH A4

Table A1. Passive Dosimetry: Maximum PPE Short-Term Dermal, Inhalation, and Total MOEs for (Ag Uses) Chlorpyrifos.

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai) [a]	Inhalation Unit Exposure (μg/lb ai) [b]	Application Rate (lb ai/A)	Dermal - Maximum PPE [b, e]		Inhalation - Maximum PPE [c, e]		Total MOE
				Daily Dose (mg/kg/day)	MOE	Daily Dose (mg/kg/day)	MOE	
Mixer/Loader Exposure								
Mixing/loading liquids for aerial and/or chemigation applications (1a)	0.017	0.24	Cranberries/corn 1.5	0.13	39	0.0018	56	23
			Citrus 3.5	0.085	59	0.0012	83	34
Mixing/loading liquids for groundboom application (1b)			Predominant max 1.5	0.029	170	0.00041	240	100
			Tobacco 5.0	0.097	51	0.0014	73	30
			Sodfarm 2.0 (tobacco/potato)	0.039	130	0.00055	180	75
			Sodfarm 4.0	0.078	64	0.0011	91	38
			Sodfarm 8.0 (fire ant) @ 10 acres	0.019	260	0.00027	360	150
Mixing/loading liquids for airblast application (1c)			Citrus 6.0	0.029	170	0.00041	240	100
			Predominant max 2.0 (orchards)	0.019	260	0.00027	360	150
Mixing WP for Aerial and/or chemigation Applications (2a)	See engineering controls	See engineering controls	Predominant max 2.0 (orchards)	DAS is not supporting the WP formulation in open bag packaging; see engineering controls for the assessment of water soluble packets				
			Citrus 3.5					
Mixing WP for Groundboom Application (2b)			Predominant max (brassica) 1.0					
			Sodfarm 8.0 (fire ant) @ <1 acre					
			Sodfarm 8.0 (fire ant)@ 10 acres					
			Sodfarm 1.3					
			Sodfarm 3.0					
			Ornamental 4.0					
Mixing WP for Airblast Application (2c)			Predominant max 2.0 (orchards)					
			Citrus 6.0					

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai) [a]	Inhalation Unit Exposure (μg/lb ai) [b]	Application Rate (lb ai/A)	Dermal - Maximum PPE [b, e]		Inhalation - Maximum PPE [c, e]		Total MOE
				Daily Dose (mg/kg/day)	MOE	Daily Dose (mg/kg/day)	MOE	
Loading Granulars for Aerial Application (3a)	0.0034	0.34	Max. 1.95	0.033	150	0.0033	30	25
Loading Granulars for Ground Application (3b)			Tobacco max. 3.0	0.012	430	0.0012	86	71
			Corn typical 1.0	0.0039	1300	0.00039	260	210
			Corn max 2.0	0.0078	640	0.00078	130	110
Applicator Exposure								
Aerial (Liquids) -- Enclosed Cockpit (4a)	See engineering controls	See engineering controls	See engineering controls	See engineering controls.	See engineering controls	See engineering controls	See engineering controls	See engineering controls
Aerial (Granulars) -- Enclosed Cockpit (4b)	See engineering controls	See engineering controls	See engineering controls	See engineering controls.	See engineering controls	See engineering controls	See engineering controls	See engineering controls
Groundboom Tractor (5)	See engineering controls	See engineering controls	See engineering controls	See engineering controls.	See engineering controls	See engineering controls	See engineering controls	See engineering controls
Airblast Applicator (6)	See engineering controls	See engineering controls	See engineering controls	See engineering controls.	See engineering controls	See engineering controls	See engineering controls	See engineering controls
Tractor-Drawn Granular Spreader (7)	0.0099 (baseline)	0.24	Tobacco max. 3.0	0.014	350	0.00082	120	90
			Corn typical 1.0	0.0048	1000	0.00027	360	270
			Corn max 2.0	0.0096	520	0.00055	180	140
Seed Treatment (8)	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Dip Application (Preplant Peaches) (9)	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Flagger Exposure								
Spray Applications (10)	0.011 (Baseline)	0.07	Predominant max 2.0	0.10	50	0.00070	140	37
			Citrus 3.5	0.050	100	0.00035	290	74
Granular Applications (11)	NA	NA	Max. 1.95	0.016	320	0.00029	340	170

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai) [a]	Inhalation Unit Exposure (μg/lb ai) [b]	Application Rate (lb ai/A)	Dermal - Maximum PPE [b, e]		Inhalation - Maximum PPE [c, e]		Total MOE
				Daily Dose (mg/kg/day)	MOE	Daily Dose (mg/kg/day)	MOE	
Mixer/Loader/Applicator Exposure								
Backpack Sprayer (12)	1.6	6	Predominant max 0.0417 lb ai/gal	0.038	130	0.00014	700	110
			Bark beetle 0.08 lb ai/gal	0.073	68	0.00027	360	58
			Citrus Bark 3.5	0.080	63	0.00030	330	53
			Stump 0.03 lb ai/gal	0.027	180	0.00010	970	150
			Animal premise 0.000052 lb ai/ft2	0.0012	4200	0.00000	22,000	3500
Low Pressure Handwand (13)	0.37	6	Predominant max 0.0417 lb ai/gal	0.0088	570	0.00014	700	310
			Bark beetle 0.08 lb ai/gal	0.017	300	0.00027	360	160
			Citrus Bark 3.5	0.019	270	0.00030	330	150
			Stump 0.03 lb ai/gal	0.0063	790	0.00010	970	440
			Animal premise 0.000052 lb ai/ft2	0.00027	18,000	0.00000	22,000	10,000
High Pressure Handwand (14)	1.6	24	Min. 0.0033 lb ai/gal	Min. 0.075	66	0.0011	88	38
			Max. 0.0066 lb ai/gal	Max. 0.15	33	0.0023	44	19
Tree Trunk Spray (15)	0.31	1	Citrus Bark 3.5	0.31	16	0.0010	100	14
			Bark beetle 0.08 lb ai/gal	0.35	14	0.0011	88	12
			Pine seedling 0.16 lb ai/gal	0.71	7	0.0023	44	6
			Animal premise 0.000052 lb ai/ft2	0.0023	2200	0.00001	13,000	1900

a Max. PPE unit exposures represent the use of open systems (e.g., open pour mixing and open cab tractors) coveralls over long pants, long sleeved shirt, chemical-resistant gloves, and a dust/mist respirator (5-fold protection factor), except scenarios 7 and 10 which represents baseline dermal attire (i.e., long pants, long sleeved shirt, and no gloves) and a dust/mist respirator (5-fold protection factor).

b Max. PPE potential dermal daily dose (mg/kg/day) = [Maximum PPE dermal unit exposure (mg/lb ai) * Appl. rate (lb ai/acre) * Acres treated * 1 dermal absorption] / Body weight (70 kg). Dermal absorption is not factored into the dose because it is compared to the 21-day dermal study, and therefore, it is a "potential" dose.

c Max. PPE Potential inhalation daily dose (mg/kg/day) = [inhalation unit exposure (μg/lb ai) * 0.001 mg/μg unit conversion * max appl rate (lb ai/A or lb ai/gal) * area treated (acres or gal) * 1 inhalation absorption] / Body weight (70 kg).

e MOE = NOAEL (mg/kg/day) / Daily Dose [Where Dermal NOAEL = 5 mg/kg/day and Inhalation NOAEL = 0.1 mg/kg/day]. MOE of 100 is the target.

[d] Max. PPE Total MOE = 1/((1/Dermal MOE) + (1/Inhalation MOE)).

Table A2. Passive Dosimetry: Eng. Controls Short-Term Dermal, Inhalation, and Total MOEs for (Ag Uses) Chlorpyrifos.

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (μg/cm^2)	Application Rate (lb ai/A)	Dermal - Engineering Controls		Inhalation - Engineering Controls		Total MOE[i]
				Daily Dose (mg/kg/day) [a]	MOE[b]	Daily Dose (mg/kg/day)[d]	MOE[e]	
Mixer/Loader Exposure								
Mixing/loading liquids for aerial application (1a)	0.0086 (gloves)	0.083	Cranberries/corn 1.5	0.065	78	0.00062	160	52
			Citrus 3.5	0.043	120	0.00042	240	78
Mixing/loading liquids for groundboom application (1b)			Predominant max 1.5	**Not required, MOE target acheived using PPE**				
			Tobacco 5.0	0.049	100	0.00047	210	69
			Sodfarm 2.0 (tobacco/potato)	0.020	250	0.00019	530	170
			Sodfarm 4.0	0.039	130	0.00038	260	86
			Sodfarm 8.0 (fire ant) @ 10 acre	**Not required, MOE target acheived using PPE**				
Mixing/loading liquids for airblast application (1c)			Citrus 6.0	**Not required, MOE target acheived using PPE**				
			Predominant max 2.0	**Not required, MOE target acheived using PPE**				
Mixing WP for Aerial Application (2a)	0.0098 (gloves)	0.24	Predom. max 2.0 (orchards)	0.098	51	0.0024	42	23
			Citrus 3.5	0.049	100	0.0012	83	46
Mixing WP for Groundboom Application (2b)			Predominant max (brassica) 1.0	0.011	89	0.00027	360	200
			Sodfarm 1.3	0.015	69	0.00036	280	150
			Sodfarm 3.0	0.034	30	0.00082	120	67
			Ornamental 4.0	0.0056	180	0.00014	730	400
			Sodfarm 8.0 (fire ants)@ 10 acre	0.011	89	0.00027	360	200
Mixing WP for Airblast Application (2c)			Predominant max 2.0	0.011	89	0.00027	360	200
			Citrus 6.0	0.017	300	0.00041	240	130

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (μg/cm^2)	Application Rate (lb ai/A)	Dermal - Engineering Controls		Inhalation - Engineering Controls		Total MOE[i]
				Daily Dose (mg/kg/day) [a]	MOE[b]	Daily Dose (mg/kg/day)[d]	MOE[e]	
Loading Granulars for Aerial Application (3a)	0.00017	0.034	Max. 1.95	0.0017	3000	0.00033	300	270
Loading Granulars for Ground Application (3b)			Tobacco max 3.0	0.00058	8,600	0.00012	860	780
			Corn typical 1.0	**Not required, MOE target acheived using PPE**				
			Corn max 2.0	**Not required, MOE target acheived using PPE**				
Applicator Exposure								
Aerial (Liquids) -- Enclosed Cockpit (4a)	0.005	0.068	Predom. max 2.0 (orchards)	0.050	100	0.00068	150	17
			Citrus 3.5	0.025	200	0.00034	290	35
Aerial (Granulars) -- Enclosed Cockpit (4b)	0.0016	1.3	Max. 1.95	0.016	320	0.00066	8	8
Groundboom Tractor (5)	0.005	0.043	Predominant max 1.5	0.0086	580	0.00007	1,400	410
			Tobacco 5.0	0.029	180	0.00025	410	120
			Sodfarm 1.3	0.0074	670	0.00006	1,600	470
			Sodfarm 2	0.011	440	0.00010	1,000	310
			Sodfarm 3	0.017	290	0.00015	680	200
			Sodfarm 4	0.023	220	0.00020	510	150
			Sodfarm 8.0 @ 10 acres	0.0057	880	0.00005	2,000	610
Airblast Applicator (6)	0.019 (gloves)	0.45	Orchards 2.0	0.022	230	0.00051	190	110
			Citrus 6.0	0.033	150	0.00077	130	70
Tractor-Drawn Granular Spreader (7)	0.0021	0.22	Tobacco max. 3.0	0.0072	690	0.00075	130	110
			Corn typical 1.0	**Not required, MOE target acheived using PPE**				
			Corn max 2.0	**Not required, MOE target acheived using PPE**				
Seed Treatment (8)	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Dip Application (Preplant Peaches) (9)	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Flagger Exposure								
Spray Applications (10)	0.00022	0.007	Typical 2.0	0.0022	2300	0.00007	1,400	880
			Citrus 3.5	0.0011	4500	0.00004	2,900	1800
Granular Applications (11)	NA	NA	NA	**Not required, MOE target acheived using PPE**				

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure (μg/cm^2)	Application Rate (lb ai/A)	Dermal - Engineering Controls		Inhalation - Engineering Controls		Total MOE[i]
				Daily Dose (mg/kg/day) [a]	MOE[b]	Daily Dose (mg/kg/day)[d]	MOE[e]	
Mixer/Loader/Applicator Exposure								
Backpack Sprayer (12)	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible
Low Pressure Handwand (13)	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible
High Pressure Handwand (14)	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible
Tree Trunk Spray (15)	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible

a Engineering control unit exposures represent long pants, long sleeved shirt, and no gloves (exception - scenarios 1a, 1b, 1c, 2 a, 2b, 2c, and 6 represent handlers wearing chemical-resistant gloves) while using closed mixing systems (98 percent protection factor used for a closed granular loader) and enclosed cockpits/cabs.

b Engineering control potential dermal daily dose (mg/kg/day) = [Engineering Controls dermal unit exposure (mg/lb ai) * Appl. rate (lb ai/acre) * Acres treated * 1 dermal absorption] / Body weight (70 kg). Dermal absorption not used because the potential dose is compared to a dermal toxicity study.

c Engineering control potential inhalation daily dose (mg/kg/day) = [Inhalation unit exposure (μg/lb ai) * 0.001 mg/μg unit conversion * max appl rate (lb ai/A or lb ai/gal) * area treated (acres or gal) * 1 inhalation absorption] / Body weight (70 kg).

e MOE = NOAEL (mg/kg/day) / Potential Daily Dose [Where Dermal NOAEL = 5 mg/kg/day and Inhalation NOAEL = 0.1 mg/kg/day]. MOE of 100 is the target.

d Engineering control Total MOE = 1/((1/Dermal MOE) + (1/Inhalation MOE)).

Table A3. Exposure Scenario Descriptions of the Exposure and Risk Mitigation Measures for Agricultural Uses of Chlorpyrifos	
Exposure Scenario (Number)	**Comments[b]**
Mixer/Loader Exposure	
Mixing All Liquids (1a,b,c)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.
Mixing Wettable Powder (2a,b,c)	
Loading Granulars (3a,b)	
Applicator Exposure	
Aerial equipment - enclosed cockpit (liquids) (4a)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.
Aerial equipment - enclosed cockpit (Granulars) (4b)	
Groundboom Tractor (5)	
Airblast Applicator (6)	
Tractor-drawn Granular Spreader (7)	
Seed Treatment (8)	No Data
Dip Application (Preplant Peaches) (9)	No Data

Table A3. Exposure Scenario Descriptions of the Exposure and Risk Mitigation Measures for Agricultural Uses of Chlorpyrifos	
Exposure Scenario (Number)	**Comments[b]**
Flagger	
Spray Applications (10)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.
Granular Applications (11)	
Mixer/Loader/Applicator	
Backpack Sprayer (12)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.
Low Pressure Handwand (13)	
High Pressure Handwand (14)	
Tree Trunk Sprayer (15)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.

Note: The Baseline exposure for mixer/loaders include chemical resistant gloves.

[a] Standard Assumptions based on an 8-hour work day as estimated by OREB. BEAD data were not available.

[b] "Best Available" grades are defined by OREB SOP for meeting Subdivision U Guidelines. Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B, and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High =grades A and B and 15 or more replicates per body part;
Medium =grades A, B, and C and 15 or more replicates per body part; and
Low = grades A, B, C, D, and E or any combination of grades with less than 15 replicates.

Table A4. Short-Term Biological Monitoring for Agricultural Uses of Chlorpyrifos							
Exposure Scenario (Number)[a]	**Average Unit Dose[b] (mg/kg/lb ai)**	**Amount ai handled[c]**		**Clothing and Equipment Scenario Monitored**	**No. of Obs.**	**Daily Dose[d] (mg/kg/day)**	**MOE[e]**
		Rate (lb ai/A)	**Acres**				
Mixer/Loader Risk							
Mixing Liquids for Aerial Application (1a)	3 x 10 $^{-6}$ (lognormal - geo mean)	1.5 Corn Cranberries	350	Open pour liquids; cotton coveralls, cotton T-shirt, briefs, socks, eye protection, chemical-resistant nitrile gloves, chemical-resistant apron, and chemical-resistant knee high boots	14	0.0016	94
		3.5 Citrus	100			0.0011	140
Mixing All Liquids for Groundboom Application (1b)	6.7 x 10^{-5}	1.5 Predom. Max	80	Open pour liquids; cotton coveralls over T-shirt and briefs, rubber boots, baseball cap, and chemical resistant gloves	3	0.0080	19
Mixing All Liquids for Airblast Application (1c)	6.0 x 10^{-5}	2.0 Orchard	40	Open pour liquids; denim coveralls over short-sleeved shirt, long-pants, T-shirt and briefs, chemical resistant gloves, and a respirator	15	0.0048	31
		6 citrus	20			0.0072	21
Mixing WP for Groundboom Application (2b)	3.9 x 10^{-4} (Open bag not supported by DAS)	2.0 Orchards	80	Open pour wettable powder; cotton coveralls over T-shirt and briefs, rubber boots, baseball cap, chemical resistant gloves, and ½ face respirator	6	0.062	2
Applicator Risk							
Groundboom Tractor (5)	6.1 x 10^{-5}	1.5	80	Open cab; cotton coveralls over T-shirt and briefs, and baseball cap	9	0.0073	20
Airblast (6)	9.1 x 10^{-5}	2.0	40	Open cab; denim coveralls over short-sleeved shirt, long-pants, T-shirt and briefs, chemical resistant gloves, and a respirator	15	0.0073	21

Table A4. Short-Term Biological Monitoring for Agricultural Uses of Chlorpyrifos							
Exposure Scenario (Number)[a]	Average Unit Dose[b] (mg/kg/lb ai)	Amount ai handled[c]		Clothing and Equipment Scenario Monitored	No. of Obs.	Daily Dose[d] (mg/kg/day)	MOE[e]
		Rate (lb ai/A)	Acres				
Mixer/Loader/Applicator Risk							
Granular Loading Combined with Tractor-Drawn Spreader (Scenarios 3b and 7 combined)	1.0×10^{-5}	Typ. 1.0	80	enclosed cab, various configurations of closed windows to open doorways; cotton coveralls over T-shirt and briefs, socks and shoes		0.0008	190
		Max 2.0				0.0016	94
Backpack (Greenhouse) (12)	2.7×10^{-3}	0.0417 lb ai/gal	40 gal	Solo backpack sprayer; cotton coveralls over T-shirt and briefs, rubber boots, baseball cap, and chemical resistant gloves	2	0.0045	33
Low Pressure Handwand (Greenhouse) (13)	1.7×10^{-3}	0.0417 lb ai/gal	40 gal	Gilmour 101P, manual sprayer; cotton coveralls over T-shirt and briefs, rubber boots, baseball cap, and chemical resistant gloves	1	0.0028	54
High Pressure Handwand (Greenhouse) (14)	3.7×10^{-3}	Min. 0.0033 lb ai/gal	1,000 gal/day	Six of the 13 test subjects wore neoprene rain jacket/pants, ½ face respirator, face shield, cotton coveralls over T-shirt and briefs, and chemical resistant gloves. The remaining 7 test subjects wore cotton coveralls over T-shirt and briefs, and chemical resistant gloves.	13	Min. 0.011	Min 14
		Max. 0.0066 lb ai/gal				Max. 0.023	Max. 7

a Data source for exposure scenarios 1a is MRID 447393-02; 1b, 2b, 5 is MRID No. 429745-01; exposure scenarios 1c and 6 is MRID No. 431381-02; exposure scenarios 12, 13, and 14 is MRID No. 430279-01; and exposure scenarios 3b and 7 combined is MRID No. 444835-01.

b All unit dose values are reported as the arithmetic means; except scenario 1a (lognormal -- geo. Mean). The results are reported as "unit doses" to extrapolate to the label maximum rates.

c Application rates are the maximum labeled rates found on EPA Reg. Nos. 62719-163, -39, -221, -23, -245, -255 -34 -79 -72 -166 -220; 34704-66; and greenhouse label 499-367. Not all rates are reflected from Table 3 because none of the MOEs approach 100.
Daily acres treated are based on HED's estimates of acreage that would be reasonably expected to be treated in a single day for each exposure scenario of concern.

d Daily Dose (mg/kg/day) = Unit Dose (mg/kg/lb ai) x Appl. Rate (lb ai/A or lb ai/gal) x Amount handled (acres or gallons).

e MOE = NOAEL 0.15 mg/kg/day / Daily Dose (mg/kg/day). Where the 21-day dermal NOAEL of 5 mg/kg/day was adjusted by multiplying by the 3 percent dermal absorption to convert the short-term duration to an internal dose of 0.15 mg/kg/day. A target MOE is set at 100.

APPENDIX B

SHORT- AND INTERMEDIATE-TERM POSTAPPLICATION EXPOSURE/RISK

TABLES B1 THROUGH B10

Table B1. Short-Term (Up to 1 Month) REIs for Potential Dermal Contact Rates and Crop Groupings Based on an Application Rate of 1 lb ai/acre.

DAT[a]	Low Exposure Potential[b] Tc = 2,500 cm^2/hour			Medium Exposure Potential[b] Tc = 4,000 cm^2/hour			High Exposure Potential[b] Tc = 10,000 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]
0	0.60	0.171	29	1.25	0.57	9	1.1	1.3	4
1	0.033	0.0094	530	0.0308	0.014	360	0.0196	0.022	220

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Potential dermal contact rates (i.e., "Low, Medium, and High") coincide with HED's policies for default transfer coefficients and available DFR data.

c DFR data from MRID 447481-02 where "Low" is represented by sugar beets, "Medium" is represented by cotton, and "High" is represented by sweet corn. DFR data are based on an application rate of 1 lb ai/A.

d Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion *1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for "Low" is HED's default of 2,500 cm^2/hr; "Medium" is HED's default of 4,000 cm^2/hr; "High" is HED's default of 10,000 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B2. Intermediate-Term (1 to 6 Month) REIs for Potential Dermal Contact Rates and Crop Groupings Based on an Application Rate of 1 lb ai/acre.

Grouping [a]	DFR Crop [b]	Avg. DAT [c]	Avg. DFR ($\mu g/cm^2$) [d]	Avg. Absorbed Dose (mg/kg/day) [e]		MOE [f]	
				Scouts	Harvest/other	Scouts	Harvest/other
LOW	Beets	1 to 7	0.0127	3.2E-5	0.00011	930	280
MEDIUM	Cotton	1 to 7	0.00938	2.4E-5	0.00013	1,300	230
HIGH	Corn	1 to 7	0.00617	1.6E-5	0.00021	1,900	140

Note: Values rounded; calculations are based on spreadsheet analyses.

a Potential dermal contact rates (i.e., "Low, Medium, and High") coincide with HED's policies for agricultural default transfer coefficients and available DFR data.

b List of surrogate groups for which DFR data exist that are used to represent the crop grouping.

c Days after treatment (DAT). The interval that the DFR were averaged starting at the short-term REI. The shorter the interval the more conservative the exposure estimate. The intermediate-term assessment is protective of workers in treated fields for 1 to 7 days and then rotating to freshly treated fields for this interval and repeated for 6 months.

d DFR data from MRID 447481-02 where "Low" is represented by sugar beets, "Medium" is represented by cotton, and "High" is represented by sweet corn. DFR data are based on an application rate of 1 lb ai/A.

e Absorbed Dose (mg/kg/day) = [Avg. DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouting is 738 cm^2/hr measured for cauliflower; harvesting/other activities "Low" is HED's default of 2,500 cm^2/hr; "Medium" is HED's default of 4,000 cm^2/hr; "High" is HED's default of 10,000 cm^2/hr. Workers wearing long pants, long sleeved shirts, and no gloves.

f MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI. For intermediate-term calculations, the MOE is used to verify that the short-term REI is sufficiently protective for workers to be in treated fields for 1 to 6 months.

Table B3. Short-Term Restricted-Entry Intervals (REIs) for Potential Dermal Contact Rates and Crop Groupings Based on an Application Rate of 2 lb ai/acre.

DAT[a]	Low Exposure Potential[b] Tc = 2,500 cm^2/hour			Medium Exposure Potential[b] Tc = 4,000 cm^2/hour			High Exposure Potential[b] Tc = 10,000 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]
0	2.4	0.69	7	A 2 lb ai/acre rate was not identified for the crops in this grouping			2.2	2.5	2
1	0.133	0.038	130				0.0392	0.045	110

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Potential dermal contact rates (i.e., "Low, Medium, and High") coincide with HED's policies for agricultural default transfer coefficients and available DFR data.

c DFR data from MRID 447481-02 where "Low" is represented by sugar beets, "Medium" is represented by cotton, and "High" is represented by sweet corn. DFR data are based on an application rate of 1 lb ai/A.

d Absorbed Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for "Low" is HED's default of 2,500 cm^2/hr; "Medium" is HED's default of 4,000 cm^2/hr; "High" is HED's default of 10,000 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B4. Intermediate-Term (1 to 6 months) REIs for Potential Dermal Contact Rates and Crop Groupings Based on an Application Rate of 2 lb ai/acre.

Grouping [a]	DFR Crop [b]	Avg. DAT [c]	Avg. DFR ($\mu g/cm^2$) [d]	Avg. Absorbed Dose (mg/kg/day) [e]		MOE [f]	
				Scouts	Harvest/other	Scouts	Harvest/other
LOW	Beets	1 to 7	0.0254	6.4E-5	0.00022	470	140
MEDIUM	Cotton	1 to 7	0.0188	4.8E-5	0.00026	630	120
HIGH	Corn	1 to 7	0.0123	3.1E-5	0.00042	960	71
		2 to 7	0.00786	not necessary	0.00027	not necessary	110

Note: Values rounded; calculations are based on spreadsheet analyses.

a Potential dermal contact rates (i.e., "Low, Medium, and High") coincide with HED's policies for agricultural default transfer coefficients and available DFR data.

b List of surrogate groups for which DFR data exist that are used to represent the crop grouping.

c Days after treatment (DAT). The interval that the DFR were averaged starting at the short-term REI. The shorter the inteval the more conservative the exposure estimate. The intermediate-term assessment is protective of workers in treated fields for 1 to 7 days and then rotating to freshly treated fields for this interval and repeated for 6 months.

d DFR data from MRID 447481-02 where "Low" is represented by sugar beets, "Medium" is represented by cotton, and "High" is represented by sweet corn. DFR data are based on a linear extrapolation of the data monitored at 1 lb ai/A to the maximum rate of 2 lb ai/A.

e Absorbed Dose (mg/kg/day) = [Avg. DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouting is 738 cm^2/hr measured for cauliflower; harvesting/other activities "Low" is HED's default of 2,500 cm^2/hr; "Medium" is HED's default of 4,000 cm^2/hr; "High" is HED's default of 10,000 cm^2/hr. Workers wearing long pants, long sleeved shirts, and no gloves.

f MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI. For intermediate-term calculations, the MOE is used to verify that the short-term REI is sufficiently protective for workers to be in treated fields for 1 to 6 months.

Table B5. Short-Term (Up to 1 Month) Restricted-Entry Intervals (REIs) for Scouts, Pruners, and Harvesters in Chlorpyrifos Treated Citrus Orchards.

DAT[a]	DFR[c] (μg/cm^2)	Scouts[b] Tc = 1,000 cm^2/hour		Wet Pruners[b] Tc = 3,213 cm^2/hour		Dry Pruners[b] Tc = 1,371 cm^2/hour		Harvesting[b] Tc = 6,891 cm^2/hour	
		Dose[d] (mg/kg/day)	MOE[e]	Dose[d] (mg/kg/day)	MOE[e]	Dose[d] (mg/kg/day)	MOE[e]	Dose[d] (mg/kg/day)	MOE[e]
0	0.947	0.11	46	0.35	14	0.15	34	0.75	7
1	0.520	0.059	84	0.19	26	0.082	61	0.41	12
2	0.286	0.033	150	0.10	48	0.045	110	0.23	22
3	0.157	-	-	0.058	87	-	-	0.12	40
4	0.086	-	-	0.032	160	-	-	0.068	74
5	0.047	-	-	-	-	-	-	0.037	130

Note: Values rounded; calculations are based on spreadsheets.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Citrus scout transfer coefficient is HED's default, pruners and harvester transfer coefficient are based on the data in MRID 430627-01.

c Citrus DFR data are from MRID 430627-01 (all three sites combined); the DFR data were generated at the maximum labeled rate of 6 lb ai/A, no application rate adjustments necessary.

d Daily Dermal Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouts is HED's default of 1,000 cm^2/hr; wet pruning is 3,213 cm^2/hr; dry pruning is 1,371 cm^2/hr and harvesting is 6,891 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Daily Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B6. Intermediate-Term (1 to 6 Months) Restricted-Entry Intervals (REIs) for Scouts, Pruners, and Harvesters in Chlorpyrifos Treated Citrus Orchards.

Activity [a]	Comment[b]	Avg. DAT [c]	Avg. DFR (μg/cm^2) [d]	Avg. Absorbed Dose (mg/kg/day) [e]	MOE [f]
Scouts	Decline curve based on all data points (i.e., 0, 1, 2, 4, 5, 7, 14, 21, 35, and 40 DAT)	2 to 32	0.0385	0.00013	230
Pruners - Dry Conditions		2 to 32	0.0385	0.00018	170
Pruners - Wet Conditions	Second part of decline curve based data points after short-term REI (i.e., 5, 7, 14, 21, 35, and 40 DAT)	5 to 35	0.0125	0.00014	220
Harvest		5 to 35	0.0125	0.00030	100

Note: Values rounded; calculations are based on spreadsheet analyses.

a Citrus scout transfer coefficient is HED's default, pruners and harvester transfer coefficient are based on the data in MRID 430627-01

b Comments - Represents the section of the decline curve the average residues were derived. For example, the short-term REI for harvesters is 5 days, and therefore, workers can be in the treated fields from 5 days on and the appropriate decline curve is derived from the data collected from 5 to 40 DAT..

c Days after treatment (DAT). The interval that the DFR were averaged starting at the short-term REI. The shorter the inteval the more conservative the exposure estimate. The intermediate-term assessment is protective of workers in treated fields for 30 days and then rotating to freshly treated fields for this interval and repeated for 6 months.

d Citrus DFR data are from MRID 430627-01 (all three sites combined); the DFR data were generated at the maximum labeled rate of 6 lb ai/A, no application rate adjustments necessary.

e Absorbed Dose (mg/kg/day) = [Avg. DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouts is HED's default of 1,000 cm^2/hr; wet pruning is 3,213 cm^2/hr; dry pruning is 1,371 cm^2/hr and harvesting is 6,891 cm^2/hr. Workers wearing long pants, long sleeved shirts, and no gloves.

f MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI. For intermediate-term calculations, the MOE is used to verify that the short-term REI is sufficiently protective for workers to be in treated fields for 1 to 6 months.

Table B7. Short-Term (Up to 1 Month) Restricted-Entry Intervals (REIs) for Scouts and Harvesters in Chlorpyrifos Treated Tree Nut & Fruit Orchards.

DAT[a]	DFR[c] ($\mu g/cm^2$)	Scouts[b] Tc = 1,000 cm^2/hour						Harvesting[b] Tc = 6,891 cm^2/hour					
		Dose[d] (mg/kg/day)			MOE[e]			Dose[d] (mg/kg/day)			MOE[e]		
		Almond	Apple	Pecan	Almond	Apple	Pecan	Almond	Apple	Pecan	Almond	Apple	Pecan
0	0.834	0.095	0.077	0.0096	52	64	520	0.66	0.53	0.066	8	9	76
1	0.458	0.052	0.035	-	96	140	-	0.36	0.24	0.038	14	21	130
2	0.251	0.029	-	-	170	-	-	0.20	0.11	-	25	46	-
3	0.138	-	-	-	-	-	-	0.11	0.050	-	46	100	-
4	0.076	-	-	-	-	-	-	0.060	-	-	84	-	-
5	0.041	-	-	-	-	-	-	0.033	-	-	150	-	-

Note: Values rounded; calculations are based on spreadsheets.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Scout transfer coefficient is HED's default, citrus harvester transfer coefficient based on the data in MRID 430627-01. These Tc are used as a range-finder to assess potential high-end exposure; nut crops such as pecans are not harvested by hand, therefore, activity-specific transfer coefficients will be used when the ARTF submit the appropriate data.

c DFR data from MRID 447481-01 (all three sites combined) are used; data are preliminary, they are currently under review by HED.

d Daily Dermal Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouts is HED's default of 1,000 cm^2/hr and harvesting is 6,891 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Daily Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B8. Intermediate-Term (1 to 6 Months) Restricted-Entry Intervals (REIs) for Scouts and Harvesters in Chlorpyrifos Treated Tree Nut & Fruit Orchards.

Crop [a]	Comment [b]	Avg. DAT [c]	Avg. DFR ($\mu g/cm^2$) [d]	Avg. Absorbed Dose (mg/kg/day) [e]		MOE [f]	
				Scout	Harvest	Scout	Harvest
Almonds	Second part of decline curve based on sampling intervals from 7, 14, 21, 28 and 35 DAT	7 to 37	0.0116	--	0.00027	--	110
	Full curve based on sampling intervals of 0, 1, 2, 4, 7, 14, 21, 28, and 35 DAT	2 to 32	0.011	3.8E-5	--	800	--
Apples	Second part of decline curve based on sampling intervals from 4, 7, and 14 DAT (other intervals ND)	4 to 34	0.00457	--	0.00011	--	280
	Full curve based on sampling intervals of 0, 1, 2, 4, 7, and 14 DAT (all other intevals nondetect)	1 to 31	0.018	6.2E-5	--	490	--
Pecans	Second part of decline curve based data sampling intevals of 2, 4, and 7 DAT (other intervals ND)	2 to 9	0.0132	--	0.00031	--	96
	Full curve based on sampling intervals of 0, 1, 2, 4, and 7 DAT (all other intevals nondetect)	0 to 9	0.02	0.00022	--	140	--

Note: Values rounded; calculations are based on spreadsheet analyses.

a All nut and fruit tree REIs will be based on the available data for almonds, apples, and pecans.

b Comments - Represents the section of the decline curve the average residues were derived.

c Days after treatment (DAT). The interval that the DFR were averaged starting at the short-term REI. The shorter the inteval the more conservative the exposure estimate. The intermediate-term assessment is protective of workers in treated fields for 30 days and then rotating to freshly treated fields for this interval and repeated for 6 months. The average apple DFR data are only based on sampling intervals up to and including 14 because the DFR data are nondetect from 14 days and beyond. For the pecan DFR data, 1 of 3 sites were nondetect at 7 DAT and all sites nondetect afterwards.

d DFR data from MRID 447481-01 (all three sites combined) are used; data are preliminary, they are currently under review by HED. The DFR data were generated at 2 lb ai/A for almonds and pecans and 1.5 lb ai/acre for apples.

e Absorbed Dose (mg/kg/day) = [Avg. DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Scout transfer coefficient is a default of 1,000 cm2/hr. The citrus harvester transfer coefficient (i.e., 6891 cm2/hr) is based on the data in MRID 430627-01 and is used as a surrogate for harvesting nuts & fruits in trees. These Tc are used as a range-finder to assess potential high-end exposure; nut crops such as pecans are not harvested by hand, therefore, activity-specific transfer coefficients will be used when the ARTF submit the appropriate data. Workers wearing long pants, long sleeved shirts, and no gloves.

f MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI. For intermediate-term calculations, the MOE is used to verify that the short-term REI is sufficiently protective for workers to be in treated fields for 1 to 6 months.

Table B9. Short-Term Restricted-Entry Intervals (REIs) for Cauliflower at Application Rates of 1 and 2 lb ai/acre.

DAT[a]	Exposure Potential[b] Tc = 2,500 cm^2/hour					
	1 lb ai/acre			2 lb ai/acre		
	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]
0	0.639	0.18	27	1.278	0.37	14
1	0.497	0.14	35	0.995	0.28	18
2	0.387	0.11	45	0.774	0.22	23
3	0.301	0.086	58	0.603	0.17	29
4	0.23	0.067	75	0.469	0.13	37
5	0.183	0.052	96	0.365	0.10	48
6	Target MOE reached at 5 DAT			0.284	0.081	62
7				0.221	0.063	79
8				0.172	0.049	100

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Transfer coefficient is from HED's policies for default transfer coefficients.

c DFR data from MRID 429745-01 for cauliflower are based on an application rate of 1 lb ai/A; DFR data linearly extrapolated to 2 lb ai/A.

d Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion *1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) is HED's default of 2,500 cm^2/hr.

Table B10. Intermediate-Term (1 to 6 Months) Restricted-Entry Intervals (REIs) for Scouts and Harvesters in Chlorpyrifos Treated Cauliflower.

Crop [a]	Comment[b]	Avg. DAT [c]	Avg. DFR ($\mu g/cm^2$) [d]	Avg. Absorbed Dose (mg/kg/day) [e]		MOE [f]	
				Scout	Harvest	Scout	Harvest
Measured Cauliflower DFRs at **1 lb ai/acre**							
Cauliflower	Full curve, all sampling intervals	1 to 31	0.0724	0.00018	--	160	--
	Second part of decline curve based on sampling intervals from 5, 7, 14, and 21 DAT	5 to 35	0.0871	--	0.00041	--	73
		7 to 35	0.057	--	0.00027	--	110
Cauliflower DFRs Normalized (i.e., multiplied by 2) to **2 lb ai/acre**							
Cauliflower	Full curve, all sampling intervals	3 to 33	0.0439	0.00021	--	150	--
	Second part of decline curve based data sampling intervals of 5, 7, 14, and 21 DAT	8 to 38	0.0836	--	0.00039	--	76
		10 to 38	0.0547	--	0.00026	--	120

Note: Values rounded; calculations are based on spreadsheet analyses.

a Cauliflower data did not present a biphasic decline curve, rather a linear decline curve. Therefore, cauliflower is assessed separately.

b Comments - Represents the section of the decline curve the average residues were derived.

c Days after treatment (DAT). The interval that the DFR were averaged starting at the short-term REI. The shorter the interval the more conservative the exposure estimate. The intermediate-term assessment is protective of workers in treated fields for 30 days and then rotating to freshly treated fields for this interval and repeated for 6 months.

d DFR data from MRID 429745-01 for cauliflower are based on an application rate of 1 lb ai/A.

e Absorbed Dose (mg/kg/day) = [Avg. DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Harvest transfer coefficient is HED's standard value of 2,500 cm2/hour.

f MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI. For intermediate-term calculations, the MOE is used to verify that the short-term REI is sufficiently protective for workers to be in treated fields for 1 to 6 months.